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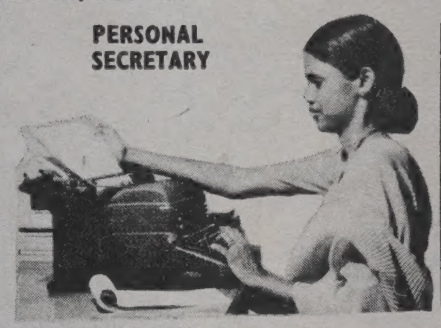

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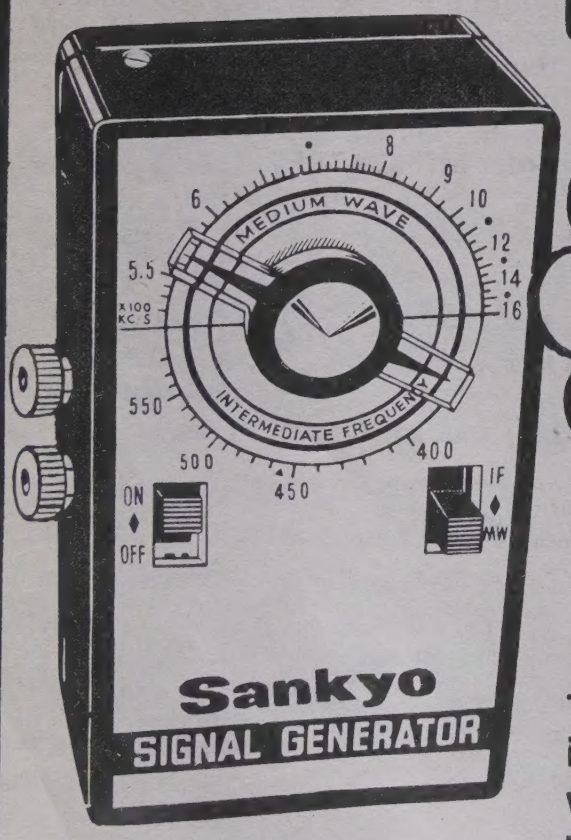

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COVER

Painted by Nana Shivalkar (The image at the top is painted from " Shaping of the earth . . . by the compasses of God " — William Blake's water colour of 1794)

Inset : The Hope Diamond (Courtesy : Smithsonian Institution)

EDITOR

SURENDR JHA

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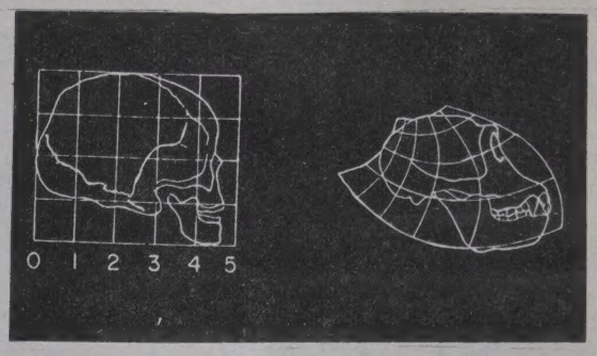
15 OF SHAPES AND SIZES
A. R. P. Rau

Much of the form of the natural world and the objects in it is a result of the physical forces that have shaped these forms. Here's a clue to why things are the way they are



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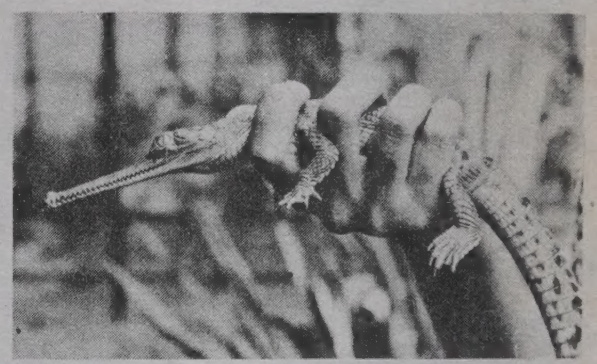
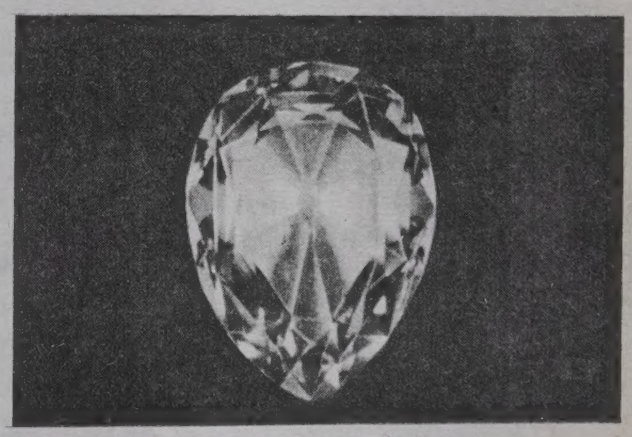
M. V. Subba Rao

A unique project is on to incubate crocodile eggs and breed the hatchlings in captivity until they can be released in their natural habitats. Here's an account of how it is being done in Orissa



36 DIAMONDS
M. L. Deshpande

Believe it or not, the diamond's closest relative is graphite — the black-lead of our pencils. Yet, what is it that makes the diamond both the ' king of gems ' and the ' monarch of industry ' ?



46 HOW GOOD ARE OUR ELECTRICAL APPLIANCES ?
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More often it's the heating appliances that make you ask that question. How about taking a look at their design and the likely ' fault ' areas ? Second article in the series

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57 ON VARIOUS TYPES OF CASSETTES

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OUR GUARANTEE

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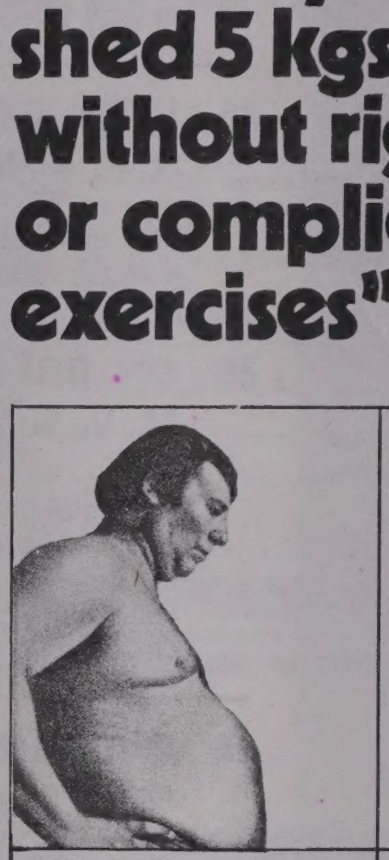
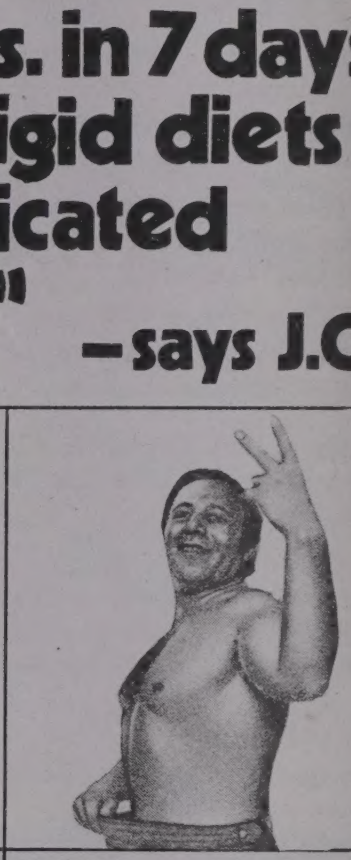
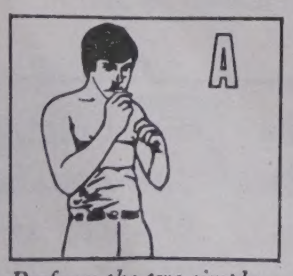


BEFORE Waist 110 cms.

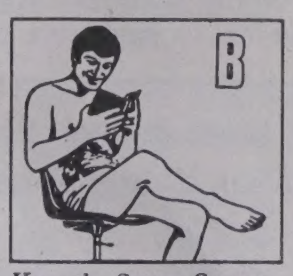


AFTER Waist 95 cms.

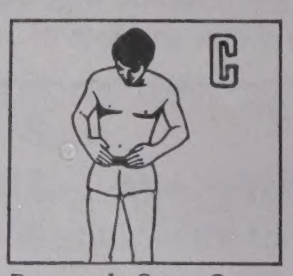
with the SAUNA SYSTEM Slimming your waistline is as easy as A.B.C.



Perform the two simple exercises with Sauna System for 10 minutes a day.



Keep the Sauna System on, after exercising for 20 minutes or so while you relax: read, listen to music etc.



Remove the Sauna System and verify the results. Your waistline will feel tighter, flatter, firmer and you may lose 3 cms. the very first time.

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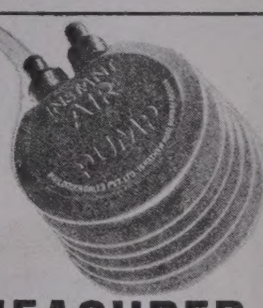

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MAILORD

Snakes, sound and the mongoose

" True or false — some beliefs and misbeliefs about venomous snakes " (June 1977) by Dr. N. E. Vad mentions that snakes cannot catch sound vibrations from the air. Recent investigations have proven that the inner ear of snakes responds electrically to airborne sounds and is quite sensitive to a limited range of airborne sounds of 100 to 500 Hz (" The problem of hearing in snakes " by E. G. Wever and J. A. Vernon, *Journal of Auditory Research*, Vol. 1, pp. 77-85, 1960, and *Biology of the Reptilia* ed. Carl Gans, Vol. 4, Acad. Press, New York, 1974). It is, however, still doubtful what role such responses play in the so-called dancing behaviour of snakes.

The question of immunity of mongoose against snake venom is another controversial issue. A number of investigators have suggested that immunity plays an important role in protecting the mongoose from the action of snake venom (*Reptiles* by A.d'A. Bellairs and John Attridge, Hutchinson University Library, London, 4th revised ed, 1975). Moreover, I have seen a mongoose crack the head of a cobra after winning a long and sustained battle. The concept of immunity is further strengthened by the fact that king snakes eat poisonous snakes of other species easily. It is, however, true that poisonous snakes are immune to their own venom. But the non-effectiveness of the venom of other species can only be explained by further immunological knowledge.

SAMAR CHAKRABARTI
Department of Zoology
Hooghly Mohsin Government College
Chinsurah 712101, West Bengal

According to Dr. Vad (" Snake-bite treatment ", p. 50, June 1977), anti-venin powder is mixed with distilled water, but I think only water for injection should be used in place of distilled water.

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Dr. Vad writes : **What I presented was a general article and not a technical paper. I had mentioned only about sound vibrations from the charmer's flute. And to this the snake does not respond. I have no experience of the airborne sounds of the type mentioned by Samar Chakrabarti. In the case of the mongoose cracking the head of the cobra, so long as the cobra venom does not enter the blood stream of the mongoose, there will be no danger to the mongoose. Even poisonous snakes are not completely immune to their own and to other species' venom. They can tolerate certain quantity of such venoms. If they are experimentally injected with more venom, they cannot stand it and die.**

About Mr. Lodi's point, only the distilled water supplied along with the anti-venin ampoule should be used (which is water for injection) and not ordinary distilled water. Ordinary distilled water may not be pyrogen-free and should not be used for injections.

Some more poisonous plants

I would like to add the following information (" Poisonous plants ", June 1977). Some people take broken seeds of *Nerium odorum* and *Nerium indicum* (' Kaniara ' in Oriya) and family Apocynaceae for suicidal purposes. Vegetative parts and fruits of many members of this family are poisonous.

Heavy doses of opium, obtained from the sap of unripe capsules of the poppy plant, *Papaver somniferum* (Papaveraceae), can cause death in a few hours. Opium contains the alkaloid morphine which, when taken in heavy doses, causes death. Water hemlock (*Cicuta*), poison hemlock (*Conium*), fool's parsley (*Aethusa*), etc of family Umbeliferae possess resins or alkaloids in lethally poisonous quantities when parts (especially the roots and fruits) are eaten.

The sap of *Metalia* has been used as an arrow poison. The latex of *Calotropis procera, C. gigantia* (Arka) causes blindness, if it comes in contact with the eyes. Intake of leaves of the above two plants is believed to cause blindness. Some species of *Asclepia* are important livestock poisons. All these plants belong to family Asclepiadeceae.

The contact insecticide pyrethrum is obtained from *Chrysanthemum coccineum* (Compositae). The pollen of rag weed *Ambrocia artemissifolia* is a primary cause of hay-fever. Many members of this family are noxious weeds. The parts of *Aconitum* or monkshood plant (Ranunculaceae) contain strong narcotics which are highly poisonous when eaten.

The foliage and fruits of some members of Coriariaceae are reported to be very poisonous. In Mexico, the fruits are used as dog poison. Leaves and roots of *Podophyllum* (Berberidaceae) are poisonous, though the fruits are edible. And several species of noxious weeds are found in the families Conculaceae and Plantaginaceae.

Among fungi, *Amanita phalloides* alone causes 90 to 95 per cent of deaths due to mushroom poisoning in Assam. It can be distinguished from the edible mushroom *Trichloma equeste* only by its characteristic volva, a cup-like remnant of the universal veil at the base of the stalk. But the volva varies from region to region.

Clitocybe and *Inocybe* contain muscarine like *Amanita muscaria* which on eating causes blurred vision, sweating, respiratory trouble, increased peristalsis, reduced heart rate, blood pressure and convulsions. The alkaloid atropine from the *Belladona* plant acts as an antidote in this case.

In the genera *Psilocybe, Palcoleus, Stropharous* and *Conocybe*, the toxin epsilocybin, a hallucinogenic agent, is found. Symptoms appear 15 minutes after consumption of such mushrooms. Poisonous and edible mushrooms look alike in many ways; there is every possibility of mistaking one for the other. Therefore, mushrooms should never be consumed before proper identification.

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Aconitum heterophyllum and *Delphinium denudatum*, which have been mentioned as poisonous (" Poisonous plants ", June 1977), are actually non-poisonous plants. *A. heterophyllum*, commonly known as ' Atis ', is among the non-poisonous aconites and is used as anti-periodic, aphrodisiac, astringent and for cough in indigenous systems of medicine. *D. denudatum*, commonly known as " Nirvishi ", is also non-poisonous ; its roots are used as tonic and in tooth ache.

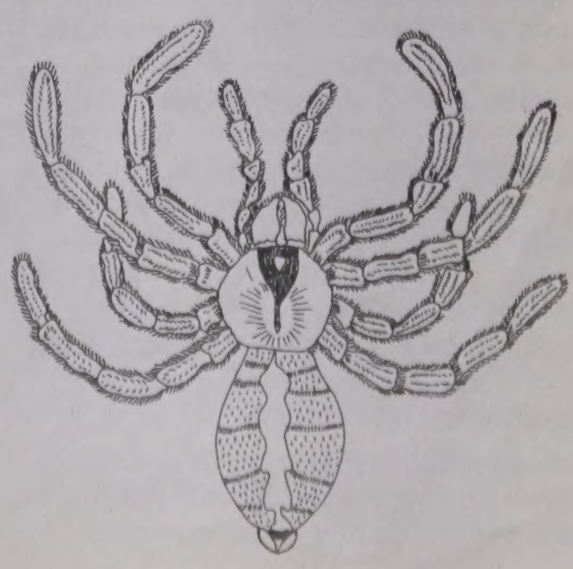
N. C. SHAH
Assistant Research Officer
CCRIMH Unit, National Botanical Gardens
Lucknow

Dr. Viswanathan writes : **The plants *A. heterophyllum* and *D. denudatum* were mentioned as examples of two genera that generally contain toxic principles. It is true that these two species are less poisonous than many other species belonging to these genera. Their use in native medicine does not always mean that they are innocuous, since the dosage of active or toxic ingredient is kept low.**

The poisonous nature of *Aconitum* and *Delphinium* plants is due to the presence of two types of diterpene alkaloids — the highly toxic ester bases like aconitine hydrolysed to C_{19} aminoalcohols and the less toxic derivatives of C_{20} alkamines, like atisine. *A. heterophyllum* and *D. denudatum* contain the less toxic type of alkaloids. There are many plants which contain alkaloids intermediate in toxicity between aconitine and atisine. The roots are generally more poisonous than the other parts of the plants. An interesting account of the use of *Aconitum* plants in arrow poisons has been recently given by Bisset in *Lloydia*, 1976, *39*, 87.

Venomous spiders

On p. 52. the box item " The child-killers," (June 1977) states that " as far as is known, there are no dangerous Arthropods in India " and on p. 55, in " The deadly midgets ", it is given



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But in the hilly regions of south India, there is a spider, commonly known as the " giant-hairy spider " or *Poecilotheria*, It is a dangerous and venomous species. Our college is situated close to the hills of the Western Ghats, and we used to see the spiders on trees during the day. We have preserved many spiders in our college museum. In south India, this spider is said to be dangerously venomous ; its bite will cause a number of boils with large swellings.

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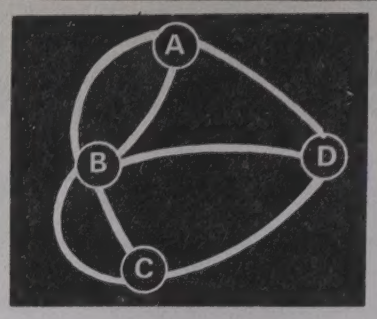

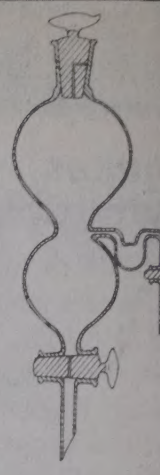

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Bombay 400 05

Going downhill on " neutral "

Mr. Rajeev Lochan Sharma's views on saving fuel in downhill driving (Letters, June 1977) betray a lack of information on motor vehicles. Using the engine to slow the vehicle while going downhill is not in any way harmful to the gear-box ; in fact, it is a standard practice. Fuel can be saved by shutting off the fuel supply simply by switching off the ignition if the vehicle is fitted with an electric fuel pump. (Of course, the petrol in the carburettor bowl will certainly go waste. This, however, does not apply to most of the two-wheelers).

That by using the engine and gear-box the vehicle speed will be reduced by a factor unacceptable to the driver is wrong. By shifting down through the gears and switching off, the vehicle can even be brought to a halt. And, as for rolling downhill in neutral with the engine idling, it is very dangerous. It may be alright on gentle slopes, but not on the kind of gradients one gets in hilly areas. In fact, this method is illegal in Britain. Besides the wear and tear on the brake-shoes and drum, prolonged use may heat up the brake-shoes to such an extent that it may lead to a brake-fade. In such an event, one may be lucky to reach home and tell everyone how it happened.

SUDARSHAN KUMAR
Niranjanpur, Saharanpur Road, Dehra Dun

There are some practical problems in using the method suggested by Mr. Sharma. These are: (1) it is illegal to put the vehicle in neutral while descending in some countries ; (2) if the speed of the vehicle or the revolutions of the engine are misjudged, one can easily ruin the engine or the transmission system by overriding the synchronisation ; (3) in an emergency, the driver is liable to get confused in the selection of the correct gear in a hurry and the result may not be pleasant ; and (4) the driver loses the benefit of the braking effect of the engine and, in case of sudden brake-failure or inadequacy, the engine may be damaged, if the speed of the vehicle is misjudged while engaging an intermediate gear.

In fact, the best method to negotiate a downgrade is to roll down in the same gear in which it should have climbed, engine alive and engaged. All motoring guides and manuals suggest this. More information can be found in *The Penguin Car Handbook* by R. Ireson, pp. 167-69 and p. 253.

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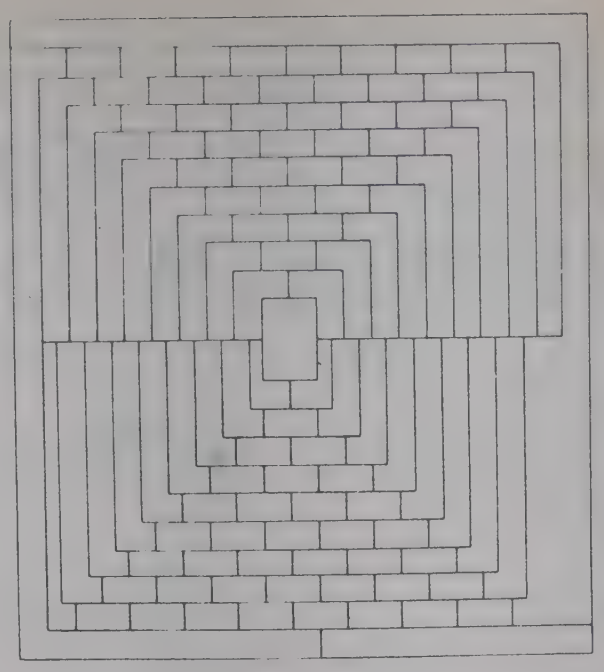
The four colour problem

This refers to the " Four colour conjecture " (August 1977). A couple of years ago *Scientific American* said that two US mathematicians, after experimenting for a number of years with the help of a computer, had come up with a plane figure in which four colours are not adequate. The figure is reproduced below. It looks like it cannot be coloured with only four colours. The readers may try to colour it, and any successful results may be published.



There must be a snag somewhere. Either the four colour theorem stands or there exists at least one plane figure for which four colours are insufficient. It is quite possible that the mathematicians who have proved the theorem have overlooked an error, or it is also possible that the accompanying figure can be coloured with four colours. The issue cannot be considered as closed.

P. MOHAMED
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What awed me most was the reference to Apple and Hakin's 400-page solution of the " Four colour conjecture " which appears fatuous to the untrained eye but which was enough to dumbfound the world's greatest brains for a century. That Apple and Hakin should have included a section in their papers to prove how it is impossible to reduce the number of pages by following their methods is even more fascinating. One wonders, however, why the two scholars did not exclude this section from their thesis, which would have automatically reduced the number of pages and saved them the trouble of proving the irrelevant proposition. But that is how scientists are — quizzical and eccentric — and that is one reason why we admire them.

DEEPANKAR MAITRA
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Can we not go a step further and say that there exists at least one region in a flat map with *four* or less neighbours ? We would then not have to prove the reducibility of the minimal pentachromatic map for the case where a region has five neighbours (which is what Kemp was unable to do).

P. R. REDDY
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Indian Institute of Management
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Regarding Kemp's argument, I think it is enough if we consider a region surrounded by three adjoining regions. We know that the triangle is the only figure where one side adjoins all the other sides. Any other polygon doesn't do so and a rider adjoins the two nearby sides. Thus the rider of the polygon could be coloured with three colours only. These, and a central colour — that is, four colours will suffice.

D. T. RATHINAM
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Dr. Singhi writes: The figure sent by P. Mohamed (the figure has also been sent by another reader, Job P. Pottayil), was published in *Scientific American*, April 1975, by M. Gardiner in his regular column " Mathematical Puzzles ". Gardiner had received over 1,000 letters on this. No one had caught his "April Fool " joke. In the next issue, Gardiner made it clear that this was just a joke.

Incidentally, I had made it clear in the article that Apple-Hakin's proof of the four colour theorem is only proof for its existence. Given a flat map, four-colouring it may be quite difficult, though theoretically it should be possible in view of Apple-Hakin's result. Mathematicians have also considered the problem of actually producing a colouring of any given map. This problem has been proven to be an NP-complete problem. Roughly speaking, this means that there are maps for which producing a colouring may require quite a large amount of time, millions of years, even if one uses computers.

Mr. Reddy asks whether it is possible to prove that any flat map has a region which has four or less adjoining regions. It's not possible ; there are flat maps which have no such regions. One such map may be obtained by drawing a dodecahedron on a sphere or a plane. All its regions are pentangular.

And thanks to Mr. Maitra for admiring scientists so much.

Higher or lower ?

Evidence presented in the article " The jumping genes " (June 1977) forces us to agree that some genes in some cases do jump. But we don't agree that *Drosophila* is a lower organism (p. 20), because we know for sure that *Drosophila* is a higher organism.

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Haryana Agricultural University
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SNEH PRABHA
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New Delhi 110 001

The second para in column 3, p. 20, should, in fact, read, " The genetic evidence is that in *higher* organisms like *Drosophila* . . . . . ". We did mean that *Drosophila* is a higher organism, as is clear from the previous paragraph where the structural evidence in higher organisms has been presented. The oversight is regretted.—Ed.

Aero-alternator weight

There was an error in the data I had sent you on the aero-alternator (" Bicycle without a dynamo ", Ideas & Inventions, p. 43, September 1977) ; the weight of the contraption is 1.8 kg, and not 4 grams. I regret the error.

M. P. MATHEWS
House No. 55/A, 6th Cross, HMT Layout
Bangalore 560 054

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But in the hilly regions of south India, there is a spider, commonly known as the " giant-hairy spider " or *Poecilotheria*, It is a dangerous and venomous species. Our college is situated close to the hills of the Western Ghats, and we used to see the spiders on trees during the day. We have preserved many spiders in our college museum. In south India, this spider is said to be dangerously venomous ; its bite will cause a number of boils with large swellings.

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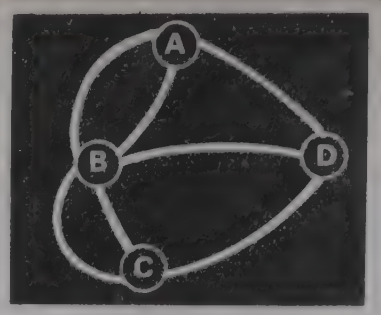

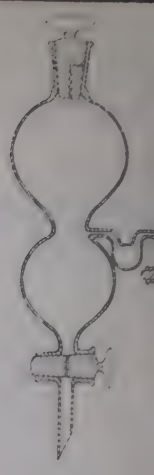

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That by using the engine and gear-box the vehicle speed will be reduced by a factor unacceptable to the driver is wrong. By shifting down through the gears and switching off, the vehicle can even be brought to a halt. And, as for rolling downhill in neutral with the engine idling, it is very dangerous. It may be alright on gentle slopes, but not on the kind of gradients one gets in hilly areas. In fact, this method is illegal in Britain. Besides the wear and tear on the brake-shoes and drum, prolonged use may heat up the brake-shoes to such an extent that it may lead to a brake-fade. In such an event, one may be lucky to reach home and tell everyone how it happened.

SUDARSHAN KUMAR
Niranjanpur, Saharanpur Road, Dehra Dun

There are some practical problems in using the method suggested by Mr. Sharma. These are: (1) it is illegal to put the vehicle in neutral while descending in some countries; (2) if the speed of the vehicle or the revolutions of the engine are misjudged, one can easily ruin the engine or the transmission system by overriding the synchronisation; (3) in an emergency, the driver is liable to get confused in the selection of the correct gear in a hurry and the result may not be pleasant; and (4) the driver loses the benefit of the braking effect of the engine and, in case of sudden brake-failure or inadequacy, the engine may be damaged, if the speed of the vehicle is misjudged while engaging an intermediate gear.

In fact, the best method to negotiate a downgrade is to roll down in the same gear in which it should have climbed, engine alive and engaged. All motoring guides and manuals suggest this. More information can be found in *The Penguin Car Handbook* by R. Ireson, pp. 167-69 and p. 253.

S. S. SHARMA
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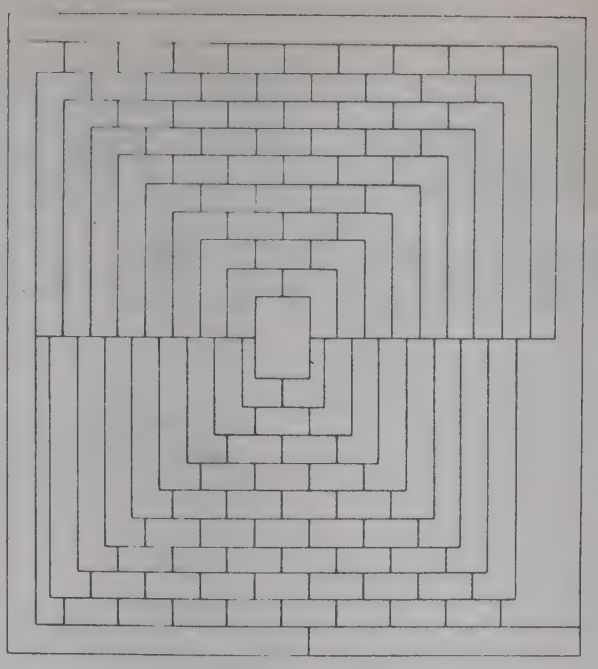
The four colour problem

This refers to the "Four colour conjecture" (August 1977). A couple of years ago *Scientific American* said that two US mathematicians, after experimenting for a number of years with the help of a computer, had come up with a plane figure in which four colours are not adequate. The figure is reproduced below. It looks like it cannot be coloured with only four colours. The readers may try to colour it, and any successful results may be published.



There must be a snag somewhere. Either the four colour theorem stands or there exists at least one plane figure for which four colours are insufficient. It is quite possible that the mathematicians who have proved the theorem have overlooked an error, or it is also possible that the accompanying figure can be coloured with four colours. The issue cannot be considered as closed.

P. MOHAMED
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What awed me most was the reference to Apple and Hakin's 400-page solution of the "Four colour conjecture" which appears fatuous to the untrained eye but which was enough to dumbfound the world's greatest brains for a century. That Apple and Hakin should have included a section in their papers to prove how it is impossible to reduce the number of pages by following their methods is even more fascinating. One wonders, however, why the two scholars did not exclude this section from their thesis, which would have automatically reduced the number of pages and saved them the trouble of proving the irrelevant proposition. But that is how scientists are — quizzical and eccentric — and that is one reason why we admire them.

DEEPANKAR MAITRA
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Can we not go a step further and say that there exists at least one region in a flat map with *four* or less neighbours? We would then not have to prove the reducibility of the minimal pentachromatic map for the case where a region has five neighbours (which is what Kemp was unable to do).

P. R. REDDY
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Regarding Kemp's argument, I think it is enough if we consider a region surrounded by three adjoining regions. We know that the triangle is the only figure where one side adjoins all the other sides. Any other polygon doesn't do so and a rider adjoins the two nearby sides. Thus the rider of the polygon could be coloured with three colours only. These, and a central colour — that is, four colours will suffice.

D. T. RATHINAM
Chockalinganagar
Madurai 16

READING R.D. No.....

Dr. Singhi writes: The figure sent by P. Mohamed (the figure has also been sent by another reader, Job P. Pottayil), was published in *Scientific American*, April 1975, by M. Gardiner in his regular column "Mathematical Puzzles". Gardiner had received over 1,000 letters on this. No one had caught his "April Fool" joke. In the next issue, Gardiner made it clear that this was just a joke.

Incidentally, I had made it clear in the article that Apple-Hakin's proof of the four colour theorem is only proof for its existence. Given a flat map, four-colouring it may be quite difficult, though theoretically it should be possible in view of Apple-Hakin's result. Mathematicians have also considered the problem of actually producing a colouring of any given map. This problem has been proven to be an NP-complete problem. Roughly speaking, this means that there are maps for which producing a colouring may require quite a large amount of time, millions of years, even if one uses computers.

Mr. Reddy asks whether it is possible to prove that any flat map has a region which has four or less adjoining regions. It's not possible; there are flat maps which have no such regions. One such map may be obtained by drawing a dodecahedron on a sphere or a plane. All its regions are pentangular.

And thanks to Mr. Maitra for admiring scientists so much.

Higher or lower?

Evidence presented in the article "The jumping genes" (June 1977) forces us to agree that some genes in some cases do jump. But we don't agree that *Drosophila* is a lower organism (p. 20), because we know for sure that *Drosophila* is a higher organism.

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The second para in column 3, p. 20, should, in fact, read, "The genetic evidence is that in *higher* organisms like *Drosophila* . . . . . ". We did mean that *Drosophila* is a higher organism, as is clear from the previous paragraph where the structural evidence in higher organisms has been presented. The oversight is regretted.—Ed.

Aero-alternator weight

There was an error in the data I had sent you on the aero-alternator ("Bicycle without a dynamo", Ideas & Inventions, p. 43, September 1977); the weight of the contraption is 1.8 kg, and not 4 grams. I regret the error.

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- "How another user Teleported a gold jewel box to her, seemingly out of thin air!"
- "How a woman used this method to regain her lost youth!"
- "How a man growing bald, claims he renewed the growth of his hair with this secret!"
- "How a woman used it to bring her mate to her, without asking!"
- "How another woman summoned a man to her, out of thin air!"
- "How a man heard the unspoken thoughts of others, with this secret!"
- "How a woman saw behind walls and over great distances, with it!"
- "How a man broadcasted silent commands that others had to obey!"

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One day, to his astonishment, he discovered that he could actually broadcast silent commands, which others instantly obeyed. Using the secret he tells you about in this book, he tried it time after time—commanding others to sleep, get up and come to him, talk or not talk—and act according to his silent wishes. It worked every time!

Others Obey Silent Commands: Writing of the success of this method, one user reports the following experience :

"I willed her to pick up and eat a biscuit from a plate in a corner of the room. She did so. I willed her to shake hands with her mother. She rushed to her mother and stroked her hands....."

"No one can escape the power of this method," says Mr. de Paul.

Hears the thoughts of Others: Experimenting further with the Tele-Photo Transmitter, Jean de Paul soon found that he could 'tune in' and HEAR the unspoken thoughts of others. He says, "At first, these hearing impressions startled me, and I took them for actual speech, until I realised that people don't usually say such things aloud! And their lips remained closed."

See Beyond Walls, and Over Great distances : Then he discovered he could pick up actual sights, from behind walls and over great distances! And when he 'tuned in' he could see actual living scenes before him as clear as the picture on a television screen!

Makes Woman appear—seemingly out of thin Air : With mounting excitement, Jean de Paul launched one of the most exciting experiments in the history of psychic research. He wanted to see if the Tele-Photo Transmitter could bring him an actual material object! He chose, for this experiment, the seemingly impossible : an actual living person! He simply focused the Tele-Photo Transmitter, by dialing the object of his desire. In a flash the door burst open, and there—standing before him as real as life—was his long lost cousin!

He stared and rubbed his eyes, and looked again! There—smiling with arms outstretched in greeting—stood living proof of the most astounding discovery of the Century!

DIAL ANY TREASURE!

You'll see how to use the Tele-Photo Transmitter, to summon your desires. This special instrument—your mental equipment — requires no wires, no electricity. "Yet," says Mr de Paul, "it can teleport desires, swiftly from the invisible world." When you dial your desire—whether for riches, love, or secret knowledge —you capture its invisible, photoplasmic form, at which point "it starts to materialize!" says Mr. de Paul.

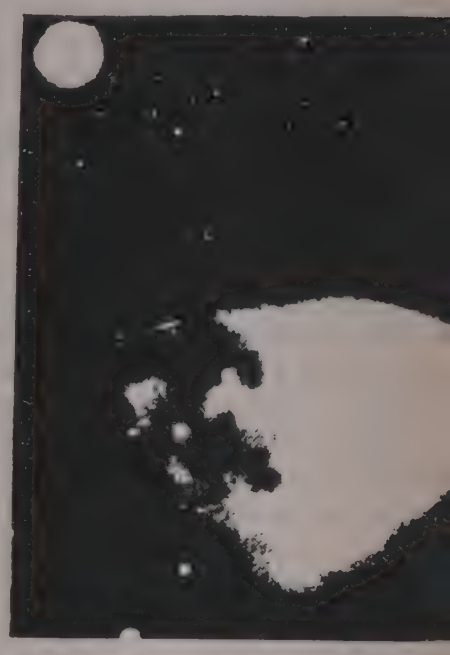
"Teleresponse Power can work seeming miracles, in your life," says Mr. de Paul. "With it, it is possible to dial any desire—called a Photo-Form—then sit back, relax and watch this powerful secret go to work!"

Instantly your life is changed : With this secret, the mightiest force in the Universe is at your command "Simply ask for anything you want," says Mr de Paul, "whether it be riches, love, fine possessions, power, friends or secret knowledge!" Suppose you had dialed Photo-Form 2 for Jewels, for example. That's what Margaret C. did, in an actual example Mr de Paul tells you about. Rich, glittering diamonds and jewels literally appeared at her feet : a pair of gold earings, which she found that morning...a surprise gift of a pearl neckalce, and matching silver bracelets...a beautiful platinum ring set with emeralds and diamonds, dropped on her front lawn!

"Almost overnight," says Mr. de Paul, "It can start to multiply riches, bring romance and love... draw favours, gifts, new friends.... or any thing else asked for! It is'nt necessary for you to understand why. What is important is that it has already worked for many others... men and women in all walks of life ...worked everytime...and it will work for you, too!"

The Power of this Method!

You'll see how Jerry D. used this method. He was broke a week before pay day. All he did, he says, was to dial Photo-Form 1. Suddenly he felt a bulge in his pocket. Lo and behold! He took out a roll of money...fives, tens, twenties...and more! Obviously, it had been placed there—but when? and by whom?



A Brand New Car Comes!

Marty C., a taxi-driver, reports tha he just dialed Photo-Form 4, sa back, relaxed, and waited for thing to happen. In a short time, grea excitement filled the house. His wi came hurrying in, saying, "We wo it! We won a car and a cash prize They just delivered it!" He got u and went to the window. There, bi and beautiful, standing in the drive way, was a brand new Cadillac!

Brings Mate Without Asking

Mrs Conrad B., reports that she wa tired of 'pursuing' her husband, a she called it. She wanted him t voluntarily do the things she longed for, take her places, show affection But he had'nt looked at her in years He would fall asleep immediately after supper, or watched the ball games, or read the papers.

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CHECK YOUR NIGHT VISION

Even if you have normal eyesight in daylight, you may be near-sighted in dim light — you may be among the 75 per cent of the population who suffer from twilight — or night-myopia. Which means, you could do with special glasses for night driving.

It has long been assumed that in total darkness our eyes focus at infinity. However, Herschel W. Leibowitz at Pennsylvania State University and D. Alfred Owens, now at the Massachusetts Institute of Technology (USA), have found that this focal distance varies remarkably with the individual — in complete darkness people focus at distances from 30 cm to 3 m, with an average of about 60 cm. Under poor illumination, a subject's point of focus shifts gradually from the appropriate target distance towards the dark focus. Under night driving conditions, the focus is approximately half-way between the two points. Therefore, the shorter a person's dark focus, the greater the night myopia.

Most subjects tested focused at a point no more than 1·8 metres away when driving at night. It follows that more

distant objects will appear as a blur. Hence, fast driving at night is apt to be risky for those with night myopia because the identification of forms and shapes, which is the special concern of the central portion of the retina, is seriously handicapped in dim light.

One solution would be to illuminate roads better, say the researchers in *Science* (29 July 1977). Another would be to use special prescription glasses and to screen drivers for night as well as daytime visual performance. In tests with glasses corrected for night-myopia, visual acuity improved by as much as 25 per cent in simulated and real night driving conditions.

TIME DILATATION IN HYPERACTIVE CHILDREN

A study of 100 children, 8 to 12 years old, has shown that for hyperactive children time passes more slowly. Since one of the major problems with such children is their short attention span, particularly in the classroom, this finding could be utilised to increase their attention spans, according to psychological researchers Betty Capella and others of the State University of New York at Buffalo, USA. (*Perceptual and Motor Skills*, June 1977.)

The group, which consisted of 75 normal children and 25 hyperactive children, was asked to press buttons to mark time intervals of 7, 15 and 30 seconds. They were told to press the buttons again when they felt that each of those periods had elapsed. The hyperactives made larger errors of estimation and the longer the time interval, the greater the error. For 30 seconds, normals estimated 26·54 seconds and hyperactives, 50·84.

MISSION TO JUPITER AND SATURN

Voyager 2, the spacecraft launched on 20 August to the giant planets Jupiter and Saturn, is NASA's most far-reaching mission. It is scheduled to reach Jupiter in July 1979. Voyager 1, which has been launched on 6 September, is scheduled to reach Jupiter a few weeks earlier. It will study the Jovian system and then make use of the planet's pull to hurl itself towards Saturn in a slingshot motion. If it completes its Saturn studies, its twin, Voyager 2 will be targeted to fly by Saturn, in August 1981, and go on to Uranus and possibly to Neptune.

Voyager is a departure from previous spacecraft. It lacks the familiar solar panels used to convert solar energy into electrical energy. These would be useless near Jupiter where the solar constant (the energy received by a square centimetre at the Earth's distance from the Sun) would be four per cent that at the Earth's orbit, or at Neptune where it is a mere 0·11 per cent. Hence, the spacecraft uses radioisotope thermoelectric generators (see sketch) carried on a boom to prevent their radiations from reaching the spacecraft.

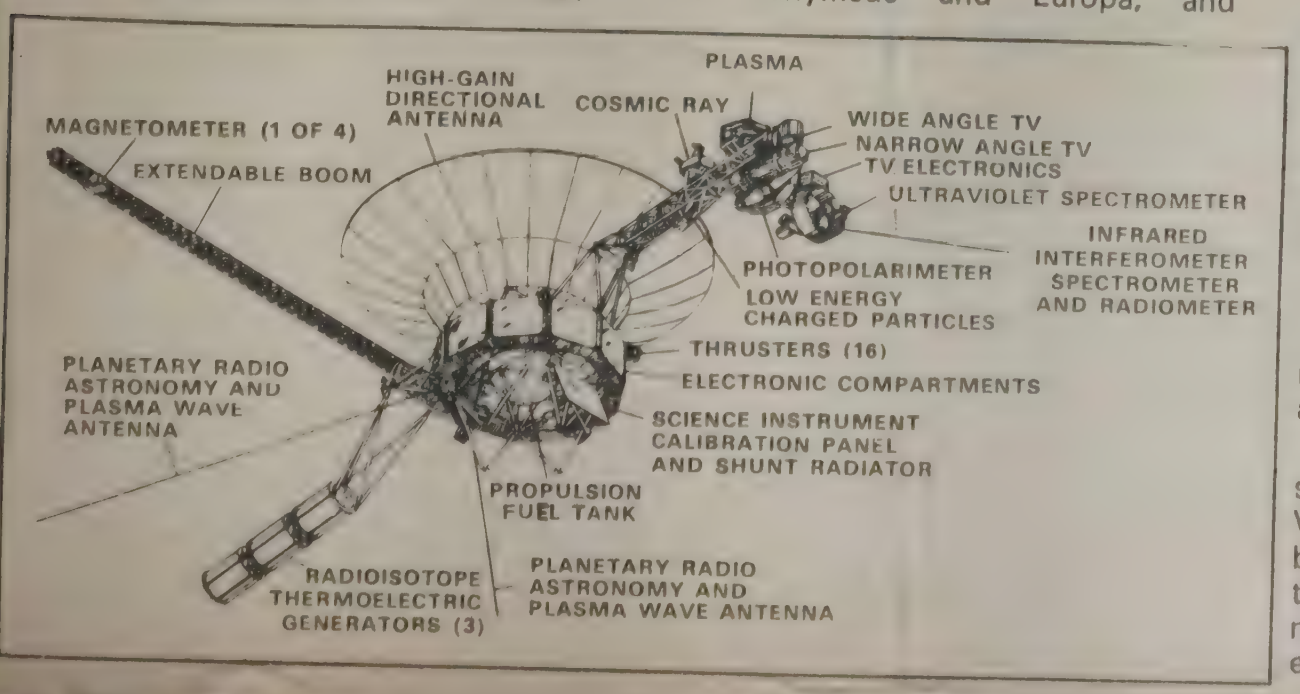
The Voyagers' TV cameras will image the planets and their satellites — which are miniature solar systems — to a detail never obtained before. Other instruments will investigate the unusual particle and magnetic field environments of the planets and the temperatures (from which their internal structure may be inferred). Voyager will pass close to the Jovian satellites, Io, Ganymede and Europa, and determine the interactions of these satellites with the planet's plasma. The 10-metre-long whip antenna will be used with a stepped-up frequency radio receiver to pick up radio emissions from the planet.

At Saturn the big question will be to confirm the presence of a magnetic field. Voyager 1 will swoop by Titan, a satellite of Saturn larger than Mercury and having (like Ganymede) a substantial atmosphere.

Other instruments are designed to probe the atmospheres of the four planets and their satellites, which together with radio science will greatly increase our understanding of the gaseous outer planets. Planetary atmospheres are important because they tell us how the planets might have formed and evolved.

If Voyager 1 is successful in its Titan encounter, Voyager 2 will be targeted to fly by Saturn in such a way that it can continue on to the planets Uranus and Neptune. A spacecraft can't be targeted to fly close to Titan and also fly to Uranus because the orbits of Titan and Uranus are in different planes. Voyager 2's mission, if successful, will have been the longest space thrust, reaching Uranus in 1886 and Neptune in about 1990

A powerful new tool employed in such a multi-planet mission like Voyager is the reprogramming capability which enables spacecraft operations to be changed to fit the special needs of the different planetary encounters.



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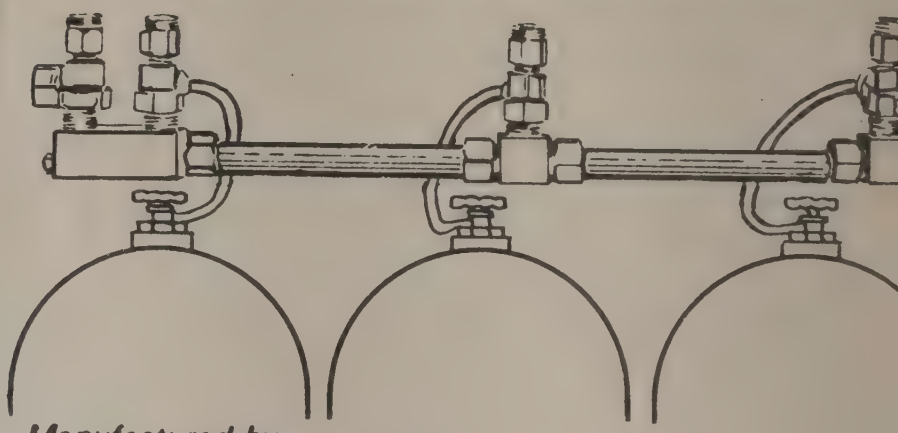

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All around us, we see a bewildering variety of shapes, structures and forms, both in man-made objects and in the natural world. Only rarely do we pause to ask ourselves why these objects take the particular shapes they do, whether there is any reason behind the forms we see, and whether there are any links between forms which, at first sight, look very different. This is particularly true of forms in the natural world because, at least for man-made objects, we sometimes do see the considerations of utility and design which have led to a particular form. The aim of this article is to set down arguments to support the premise that there is a meaning, in the sense of physics, to the forms we see around us. The forms, whether of animate or inanimate objects, are equally to be understood as quasi-mechanical effects on matter of physical forces.

This is a point of view quite different from that of ancient philosophers to whom form was a metaphysical concept. It is also a point of view that may not be very familiar to many, including natural scientists (and, perhaps, physical scientists as well), since conventional training in biology does not emphasise it. It is, however, a point of view that should be an integral element of the thinking of all of us because such an attitude can be important in understanding how and why these forms arise, and how they change or develop — the study of morphogenesis.

One man of reason who, in the early part of this century, expressed most clearly and strongly this conviction that forms in the natural world are to be understood in terms of physico-chemical forces was Sir D'Arcy Thompson. In his own eloquent words, " cell and tissue, shell and bone, leaf and flower are all so many portions and aspects of matter and it is in obedience to the laws of physics that they have been moved, moulded and conformed ". D'Arcy Thompson's monumental book *On Growth and Form* (Cambridge University Press, 1943), which should be part of everyone's education, is the seminal work in this area and is the precursor of any new developments in the study of forms that may come in the years ahead through advances in mathematics. The present article is essentially a paraphrase of the book. Throughout, many of the examples and illustrations and even direct quotes have been drawn from this book even though, to avoid repetition, this may not always be explicitly stated.

Sushma

OF SHAPES AND SIZES

A. R. P. RAU

To the Lilliputians in Jonathan Swift's story, Gulliver was a giant — scaled up in size several times. But then, if the Lilliputians were of the normal human proportions, Gulliver would have to be very large, very fat and very very heavy — according to the physical laws that govern shapes in nature. How much do we really know why things are the way they are?

At the very simplest level, simply in terms of the static aspect of forms, so much already falls into place just in terms of the dimensions of the world we live in. That surfaces are proportional to (length)^2 whereas volumes are like (length)^3 is already enough to make a lot of sense of form. There is, for instance, a small wading bird called the stilt which D'Arcy Thompson uses as an example. It weighs, on an average, 0·11 kg (4 oz) and has legs 20 cm long. If we then look at a bird such as the flamingo, which may weigh about 1·8 kg (4 lb), we can argue that since their weights — and, therefore, correspondingly their volumes — are in the ratio 1 : 16,

Fig. 1 The stilt (left) and the flamingo (right). The stilt weighs, on an average, 0·11 kg and has legs 20 cm long. The flamingo weighs about 1·8 kg and has legs about 50 cm long. This gives a weight, and, therefore, a volume ratio of 1 : 16 between the two birds, and a leg-length ratio of 1 : 2·5. This conforms to the expected dimensional proportions; volume is proportional to (length)^3, or $(2{\cdot}5)^3$ which is roughly equal to 16

corresponding lengths could be expected to be in the ratio $1 : \sqrt[3]{16}$ which is roughly 1 : 2·5, so that the flamingo should have $20 \times 2{\cdot}5 = 50$ cm long legs — as it does! Similar birds (in this case, with similar wading habits) have similar proportions and their forms can be correlated. Even in this simplest example, note that we transcend species in establishing a correlation. This is characteristic of many of the conclusions that follow when physical considerations are applied to understanding forms because the concept of species is a biological one and is irrelevant for physical considerations.

As another illustration, one can build a model of a bridge on a table with matchsticks, but if one were to build a real bridge using the same material by merely scaling up the size, the bridge would collapse. This is because the strength of a girder or matchstick varies as the cross-sectional area and, therefore, like L^2. When considering the effect of a force on something like a beam or girder, it is not the total force applied longitudinally, say, at one of the ends, that is important in determining the effect on the beam — the same force on a thick railroad rail does less damage than when it is applied to a thin piano wire. What is relevant is how the force is distributed over the cross-sectional area, the ratio of the force to the area which one calls the stress. A well-known law states that the strain produced is proportional to this stress. Hence, what determines the strength of a girder is, besides the nature of the material, its area of cross-section. But the load, which is a weight, depends on the volume and hence goes like L^3. It follows immediately that there is a relative loss in strength when one scales up the size of a column or girder. So, in building the actual bridge, one would either have to use material of different inherent strength (girders of iron instead of wood pulp) or use a larger portion of girders to other parts of the bridge than in the model.

There is an example of the latter solution in nature in the skeletal ratios (proportion of bones to the rest of the body) of land animals. The bones of animals support their structure. Since nature tends to use similar building blocks (this is a general theme that runs throughout this article and represents one of the important basic facts that governs the nature of forms), the breaking strengths of bones, be they bones of a mouse or of an elephant, are almost all the same. There is, as a result, a slight increase in the skeletal ratio in larger land animals, increasing from about 8 per cent in a mouse or a wren through 14 per cent in a dog or a goose to about 17 per cent in man. As a corollary to this necessary increase in skeletal ratios, there is a physical limit to the largest size a land animal can attain. All these elementary conclusions illustrate that quite a bit of form is simply that objects are under competing forces, some of which (like the strength of the skeletal framework) are proportional to L^2 and some (like gravity) to L^3. D'Arcy Thompson sums it up in what could be almost a fundamental theorem in morphogenesis: " *The form of an ... is a diagram of the forces acting on* ... Note that in water the force of gr... is cancelled out by the buoyant ... which helps to explain immedi... why, unlike in land animals, ... skeletal ratio is almost a constant ... porpoises all the way up to the la... whales. Also, it further follows ... the largest sea animals (whales) ... be expected to be, as they in... are, much larger than the largest ... animals (elephants).

Yet another aspect of the surf... volume ratio is illustrated by f... and vegetables. The strength of ... stalk increases as L^2 whereas the ... of gravity goes like L^3. So, in fac...

Fig. 2A The relative sizes of the front... bones of two related animals — the bison ... the gazelle (smaller). The bison is a l... animal, and its bone is much thicker comp... to the length than that of the gazelle bo...

Fig. 2B The gazelle bone, with the le... enlarged to that of the bison bone (*Phy...* National Council of Educational Researc... Training)

2A

2B

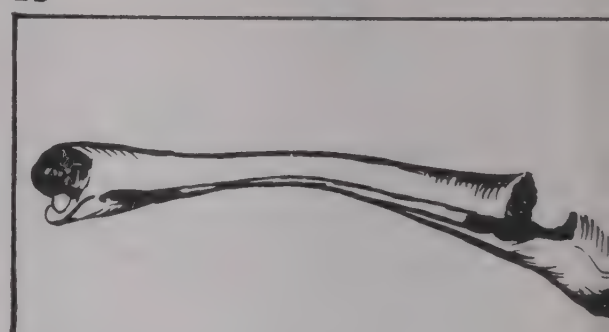
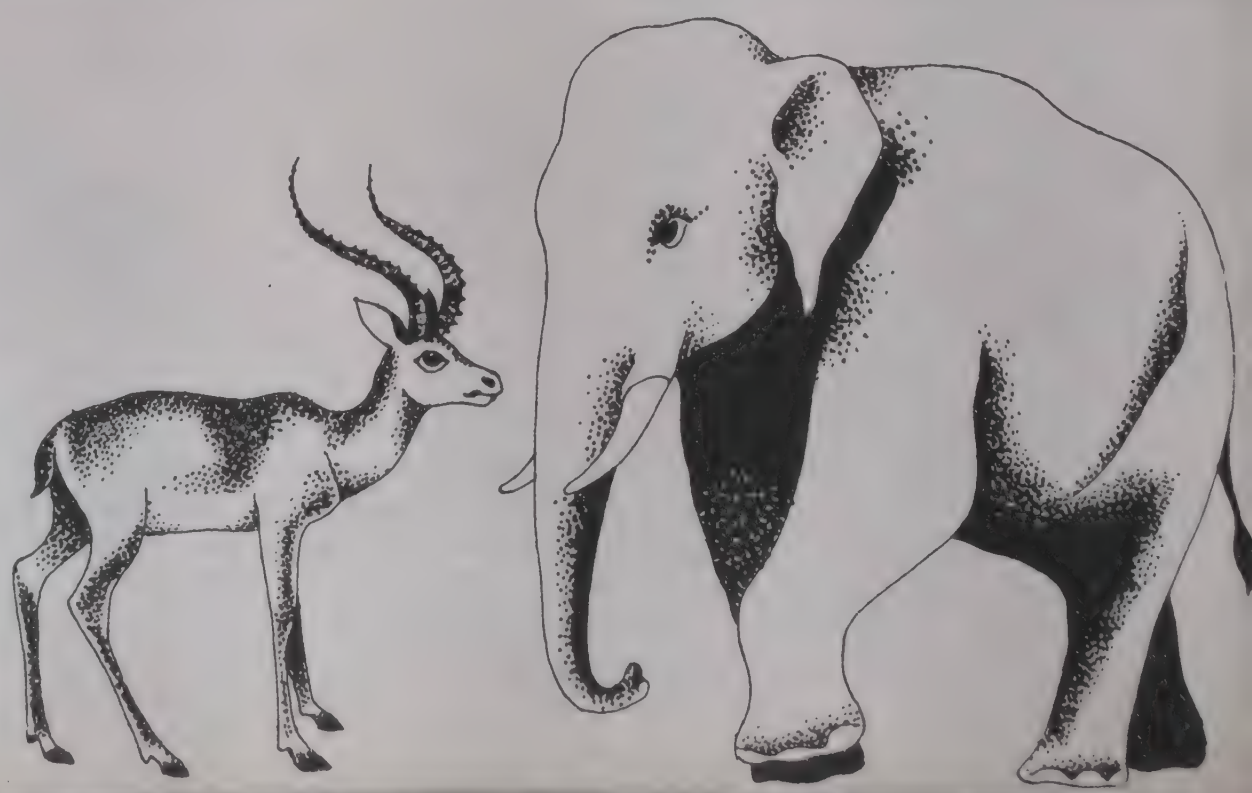


Fig. 3 (below) The gazelle and the elephant. The skeletal ratios increase for larger animals, and a large animal like the elephant has thus grown clumsy and is necessarily less graceful than the gazelle



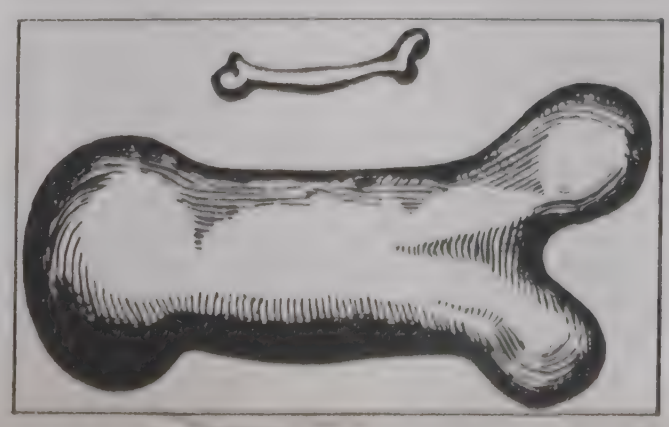
is not without reason that " tall trees do not bear large fruits on slender branches and melons and pumpkins must lie upon the ground "!

Science fiction stories of powerful, large ants making enormous tunnels at fantastic speeds are just that — fiction. What they have discounted in merely scaling up capabilities along with the size is the feature that an increase in size has a necessary effect on other characteristics and capabilities of the form so that such ants would be necessarily more sluggish than the familiar little ones that we know. That the skeletal structure increases and becomes more complicated for larger animals, that larger animals like elephants and hippos have grown clumsy at the same time as growing big and are necessarily less graceful than gazelles are all aspects of the surface/volume story. As J. B. S. Haldane puts it in a very readable little essay, " On being the right size " (*Possible Worlds*, Harper Brothers, New York, 1928), " The higher animals are not larger than the lower because they are more complicated; they are more complicated because they are bigger ". Were the pull of gravity to be increased appreciably (suppose, for instance, we were considering hypothetical beings on a large planet like Saturn or Jupiter), the majority of land animals would be short-legged or serpents. The inexorable effect of the pull of gravity is to be seen everywhere. A vertical column (say, a cylindrical one), for instance, bends under its own weight and one can show (see T. A. McMahon, " The Mechanical Design of Trees ", *Scientific American*, July 1975) that an increase in height must, for stability, be accompanied by an increase in diameter according to the relation: diameter is proportional to $(\text{height})^{3/2}$. This immediately accounts for the slender look of young trees compared to the squatter appearance of older ones. It also sets a limit to the maximum height a tree can attain (or, for that matter, why a cat's tail cannot stand straight even though a kitten's can!) when one takes into account the average density and elastic modulus of wood and the feature that the diameter is usually some reasonably small fraction of the height. Remarkably, the tallest trees in nature do, in fact, approach roughly the value one gets for such a limit set by physical considerations. This is an example of what might be a basic tenet in the study of biological forms, namely, that " the physics " sets natural limits on the variability of a certain form and that nature fully exploits this niche through biology, filling (almost) the entire niche and giving us many examples of forms close to the physical limits. The above statement also serves as a caution on how to view many of the examples and illustrations in this article. They are not to be considered as rigid theorems precisely defining the forms we see but more as guidelines around which there could be, and often is, a fair variability, though not, as a physicist would say, by orders of magnitude. Also, it is the extremes within the biological variability, such as the largest or tallest or smallest that exhibit most clearly the conclusions one arrives at on the basis of physical considerations.

To conclude this section on the static aspects, it should be kept in mind that the nature of the competing forces that determine the form of an object can vary from environment to environment. We have already seen that gravity may play little role for sea animals, unlike the dominant role it has for land animals. At another level, the very small, as in the case of tiny insects or mosquito larvae or at the even smaller level of bacteria and cells, gravity may again take a side role compared to other forces such as surface tension or viscosity. A man immediately after a bath is only a fraction of a per cent heavier than usual because of the water sticking to him, whereas a fly is twice as heavy when wet and quite helpless. This is again because the surface/volume ratio is larger, the smaller the object. In the structure of such small organisms, where surface forces like surface tension play a dominant role, one generally sees circular or spherical shapes (cells, bubbles, drops, etc), relatively less complicated shapes than at our level. Incidentally, it is interesting that again at the very largest level, such as that of planets and stars, where gravity really is all-important and dominates all specific solid state forces in matter, one again sees spherical shapes. That this happens only for very large objects is clearly illustrated by recent photographs taken by satellite missions to Mars of the two moons of Mars, Phobos and Deimos, which are only a few ten kilometres across and which show up on the pictures as very irregular objects far removed from spherical symmetry.

Fig. 4 Taller trees are proportionally thicker than shorter ones. Three large trees, a giant sequoia (left), a Douglas fir (centre) and a ponderosa pine (right), show the diameter of a tree trunk at its base increases as the height increases. The mathematical model of elastic similarity requires that the base diameter of a tree increases as the 3/2 power of the tree height. The base diameter of the sequoia tree, which has been damaged at the top, suggests that it would have grown to 91 metres (dotted line) if undamaged (*Scientific American*, July 1975)

Fig. 5 Galileo wrote that a bone of a greater length must be increased in thickness in greater proportion to retain a comparable strength. This drawing by Galileo shows his concept of scaling. The large bone is about three times longer and nine times thicker. This actually is wrong; the large bone should be only about 5·2 times thick



Dynamics

Besides the static aspects of forms discussed above, the surface/volume ratio plays a crucial role in dynamics as well. The larger the animal, the faster it can walk, and larger fishes swim faster than smaller ones. Consider walking, for instance. There is obviously an economy of effort if the legs swing at the rate of a natural period of oscillation — the pendulum rate. This rate, which varies inversely as the square root of the length of the leg, will remain the same regardless of how fast one walks. To walk quicker, we step out, increasing the stride or the amplitude of the swing but not the rate itself. The rate is only increased when we begin to run, at which time we crouch, thus reducing the pendulum length! So, in walking, the length of the stride, like any other linear dimension, is proportional to L whereas the time period of the swing goes like $\sqrt{L}$. As a result, the speed is proportional to $\sqrt{L}$. This

is called Froude's Law and is well illustrated by the fact that man can walk at about 8 kmph whereas a fly can walk some centimetres a second as one would expect from the roughly 1 : 200 ratio of their heights. Though the detailed considerations with regard to swimming are somewhat different, the same sort of dimensional result applies here as well — that the speed of a fish is roughly proportional to $\sqrt{L}$. Also to flying. The larger the bird or the aeroplane, the faster it has to fly to just stay aloft. Only a hummingbird, not a hawk, can hover! Care must be taken, however, to keep in mind that such a Froude's Law is not always applicable and is only true for what one calls streamlined flow. There are certain regimes of size and speed where the flow is drastically different and such a square-root law inapplicable. This is an aspect of a general caution in all such arguments based on physical considerations — one should be very clear on their regions of applicability.

As another interesting illustration, consider the jumping capabilities of different animals. One is often impressed by the feature that a flea can jump 200 times its own size whereas we can only jump roughly our own heights (the Olympic record is a little over 2 metres). In looking at this more closely, we see that the impulse generated by the muscles when we jump, increases as L^3 (the cross-section of a muscle multiplied by the contraction through a certain distance). The velocity of take-off, therefore, which is the impulse divided by the mass, is roughly constant, since the mass also goes like L^3. Since one knows that for a given vertical take-off velocity, all objects, regardless of their mass, reach the same height, it follows that the maximum height for the jump is the same for all animals be it a flea or a horse or a man — a few feet. Seen in relation to the body size it is, of course, much more impressive in the case of the flea than for a horse or a man.

Energy consumption

The surface/volume ratio and its character of being larger for smaller objects also affects energy considerations and the metabolic activity of animals. This follows naturally because loss of heat takes place from the surface whereas the total energy required or generated depends on the volume of the animal. Everyone is familiar with puppies huddling together for warmth. The loss of heat is more crucial the smaller the animal and, as a result, insects tend to have hard or scaly skin to cut down on evaporation losses. They also consume large quantities of food relative to their weight and, as a corollary, eat almost all the time! For mammals, where heat losses are particularly crucial, since a relatively constant temperature is to be maintained, there is as a consequence a minimum size. A mammal cannot be the size of a tiny insect. This conclusion is further sharpened when one looks at extreme environments like the Arctic regions or the oceans. The sma mammals to be found there are m larger than the smallest ones in tr cal lands. That heat considerat are more critical the smaller animal means that the relative amo of food consumed increases. A m eats its own weight of food e day whereas we can get by a fraction of ours. Not only amount consumed but the r involved, such as the heart beat the respiratory rate and the metab activity in general are speeded As a consequence, the smaller animal, the faster it dies off, or it a shorter life span. Such a direct relation between metabolic acti and life span with the size of animal is exhibited by any chart ing such comparative figures all way from the mouse to the eleph and the whale.

Sound and vision

Small animals, general, make squeakier cries th larger ones. Just on dimensional co siderations alone this is to be expect because the wavelength of the sou generated, like any length, should smaller for the smaller animal, there making the frequency higher. Part the range of sounds generated m even lie outside our range of heari — a hummingbird, for all we kno may be humming all day long. Inc dentally, that the frequency rang are different means that all the tim scales are different and a second ma mean far more to an insect than us because "far more things happe to it in a second than to us." This so of counterbalances our earlier con clusion regarding shorter lives for th smaller animals — true, but then they lead fuller lives!

Vision is another story because o an externally imposed aspect, namely that the Sun puts out a major portio of its energy in a certain band o wavelengths roughly around what w call the visible region. Hence, al animals have developed a visua acuity for this region. Further, in al of them, the rods and cones in the ey cannot vary very much in size becaus of optical limitations due to inter ference and diffraction. Here is an actual physical explanation in one instance of why nature uses simila building blocks. One can go further because, given the constancy in size of the rods and cones, the eye itsel in all animals can never be very small nor very big. This is because only a small portion of the retina is ever used in an observation and there is not much to be gained in terms o the field of view by having a large eye

Similitude

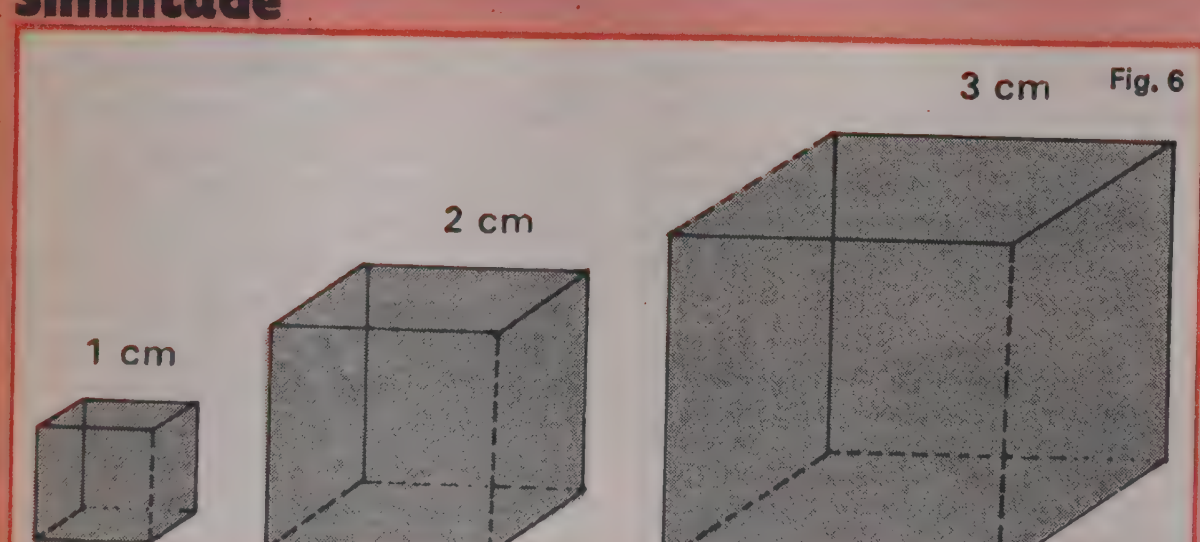


Fig. 6

A surface area is defined by two independent (mutually perpendicular) lengths and we say it has the dimensions of L^2. Any area is always measured in units like yd^2 or km^2. Similarly, a volume is defined by three independent lengths and has the dimensions of L^3. When an object in our three-dimensional world is scaled up or down in size, preserving the shape, it is simple from dimensional considerations alone, therefore, to see what happens to surface areas and volumes. For concreteness, consider a cube of side 1 cm. If all lengths are scaled up by a factor c, a bigger cube results, with the total surface area of the six faces going up from 6 cm^2 to a number c^2 times as large and with the volume increasing from 1 cm^3 to c^3 cm^3. The above example illustrates a general consideration: when length is scaled by a factor of c, *keeping shape constant*, surface area gets scaled by c^2, and volume by c^3.

A.R.P.R.

in a large animal. The biologically remarkable fact that nature has, in the course of evolution, evolved in different lines of species essentially the same kind of eye finds its explanation, therefore, along the lines of such physical arguments. Only in insects is there a slight difference. Since diffraction effects would be disastrous were they to have a single eye similar to ours which would mean a very tiny pupil, insects have compound eyes and an " aperture synthesis " of the images of all of these is an integral part of their visual system.

Function determines the form

Everyone would accept the principle that the structure of many man-made objects is guided by the functions they are supposed to perform. As a simple example, coastal cities whose importance depends on handling sea-going ships will have long narrow wharfs and jetties jutting into the water so that many ships can be handled in the harbour. The characteristic appearance, therefore, of such cities is a simple example of the geometrical fact that such a construction is the way to achieve a large perimeter for a given plane area. Similar considerations on the three-dimensional level guide nature in its design of biological forms so that much of form can be understood in terms of the functions it has to perform. Organs such as the lung and intestines which have to absorb nourishment from the outside and are thus surface-dominated in their functions take characteristic shapes involving folds, doubling-ups, complex networks and convolutions, all of which tend to increase the amount of surface for a given volume. There is roughly $1m^2$ of lung surface per kilogram of the body weight of an adult human, so that the total lung surface is the size of a tennis court! Incidentally, the inevitable constraint imposed on accommodating these large surface areas in a reasonably confined volume has repercussions on the overall appearance of the object. A small worm, which does not require that large an intestinal structure, can be reasonably straight and long but a larger animal, if it were to be linear, would have to be of an impossible length. Instead, we do not see linear shapes when we get to larger animals but rather more " filled-out " three-dimensional structures.

At the cellular level too, it is possible, and even very likely, that the same feature of the function determining the form is operative. This may lie behind the remarkable fact that biological cells are all roughly the same size. It is indeed striking that, even though in the finished forms the elephant dwarfs by several orders of magnitude the mouse or the ant, in terms of the basic cells that constitute these various forms, and all biological cells in general, there is never more than a factor of ten difference in size. This is yet another instance of nature using similar building blocks and it is very plausible that it results from the competition between the consumption of energy (which is proportional to volume) and its capture (through the surface), the difference between these being the energy available for synthesis and, thereby, the growth of the cell.

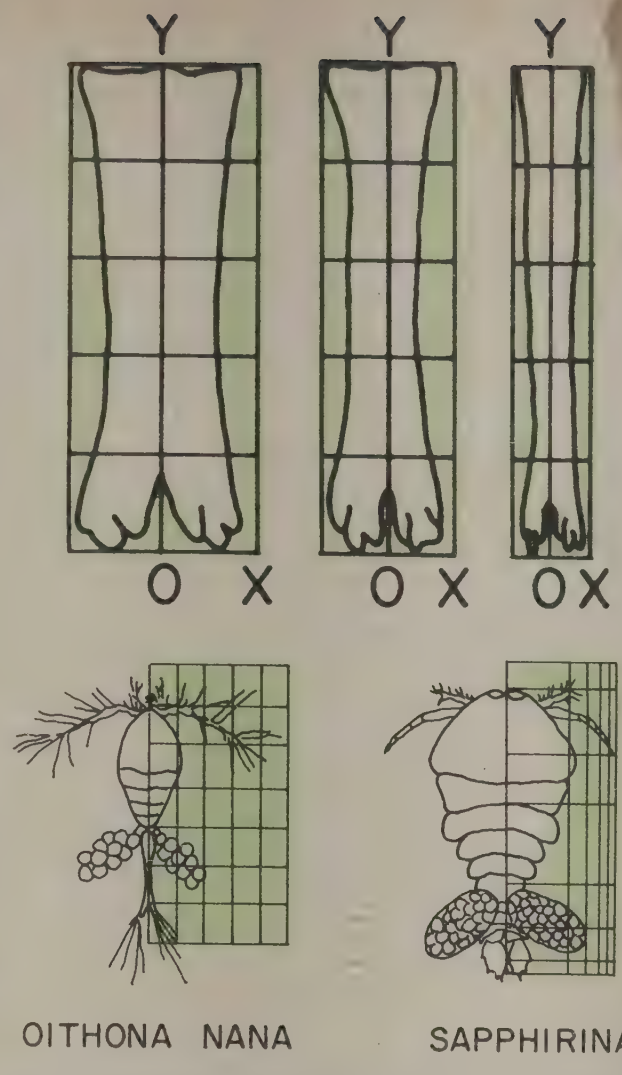


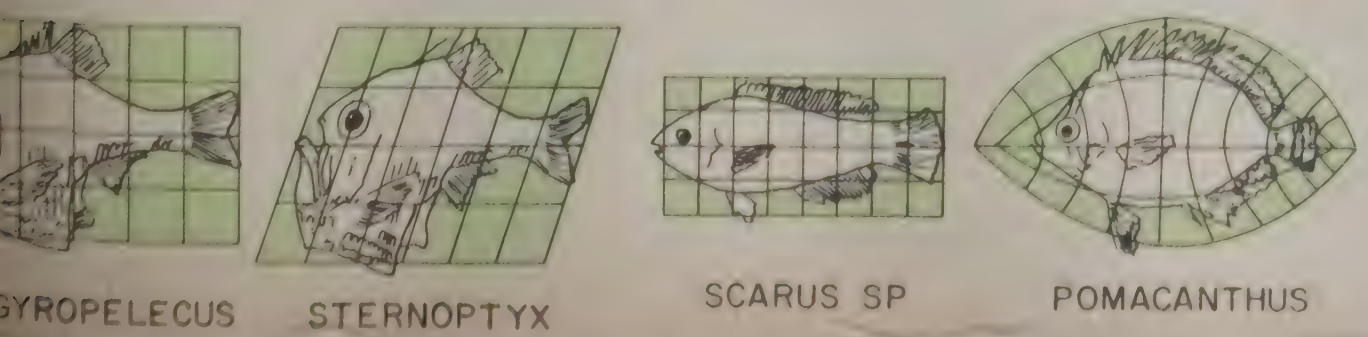
Fig. 7 (top) The cannon bones of an ox (left), a sheep (centre) and a giraffe (right) are related to each other by the scaling of the horizontal axis

Fig. 8 (above) Relation between the sizes of two copepods of different genera

Transformations

A striking aspect of forms in nature is the relationships, sometimes very simple geometrical ones, that are often to be seen between different finished forms as a whole or between parts of these forms. *On Growth and Form* contains several examples of this, as shown in the representative sample of figures given on this page that have been taken from that book. One (Fig. 7) compares the cannon bones of an ox, a sheep and a giraffe, showing that they are simply related to each other by an overall scaling of the horizontal axis. Even more striking is the one (Fig. 8) which shows the simple geometrical transformation of the axes that takes two copepods of different genera into each other, though at first sight (without the background grid, for instance) they look very different; Fig. 9 is a similar illustration of fishes of related families and, with somewhat more complicated transformations, of two sun fishes which are of different families according to their biological classification. D'Arcy Thompson also provides examples of skulls of various ungulates showing a continuous topological thread from the skulls of extinct rhinos through those of present-day rhinos to those of tapirs and horses and, most remarkably, even of rabbits which, as he says, is a clear demonstration of the close affinity of the rodents and the ungulates. Fig. 11 is another example with skulls of various apes and the link to that of man. One can in this way make this transformation study even a predictive one by thinking of a continuous topological distortion that carries one from one of these skulls to the others and looking for intermediate configurations in such a distortion, " missing links ", of which we may not have direct evidence. Another step would be to speculate on what physical parameters and changes of environmental pressures could have made the course of evolution trace such a path. The

Fig. 9 Topological illustrations of fishes of related families



presence of such simple transformational links is an illustration of Newton's words, " Nature delights in transformations ", and clearly indicates the role of topology in understanding biological forms. Yet another aspect of such transformations, applicable now not to comparing different forms, but to the various stages of growth of any specific form is best stated in D'Arcy Thompson's following words on " Nature and the glass-blower ".

" It is clear that we may account for many biological processes of development by the existence of lines of constraint which limit and channel the expansive forces of growth. There is a close parallel to the actions of a glass-blower who starts his operations with a tube which he closes at one end so as to form a whole vesicle within which his blast of air exerts a uniform pressure on all sides. The spherical conformation this would produce is modified by the resistances set up as he lets one part or the other be unequally cooled or heated. Nature also starts with a simple tube — the alimentary canal, the arterial system, the central nervous system of vertebrates. And with them nature does just what the glass-blower does and we may say no more than he. She expands the tube here, narrows it there, thickens its walls or thins them,

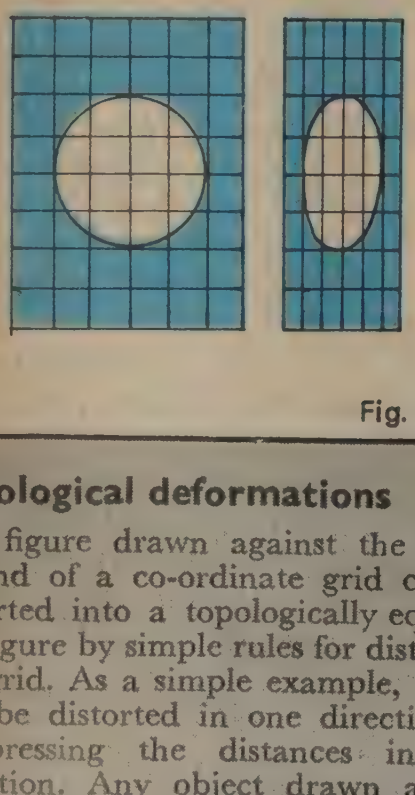


Fig. 10

Topological deformations

A figure drawn against the background of a co-ordinate grid can be distorted into a topologically equivalent figure by simple rules for distorting the grid. As a simple example, a grid can be distorted in one direction by compressing the distances in that direction. Any object drawn against that grid will take on a more elongated appearance — the circle shown becomes an ellipse. Co-ordinate axes of a system can be changed, while keeping fixed the points being described, by a mathematical formula. For example, stretching the x-axis by a factor of two, results in the co-ordinate transformation $x' = \frac{1}{2}\,x$, $y' = y$. More complicated transformations like rotating the axes, or stretching them by different amounts, or a combination of a rotation and a stretch will result in more complicated transformation formulas.

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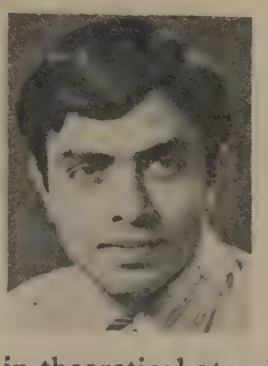
Fig. 11 A human skull and that of the chimpanzee and the baboon

blows off a lateral shoot, bends the tube, infolds the walls, etc. The gravitational field is part of the complex fields of force which influence and determine the forms of the organism ".

It would be interesting to carry out experiments on the growth of biological organisms in a weightless condition or in conditions of artificial gravity. This may shed considerable light on the nature of the influence of external forces during the process of growth. Sometimes gravity may not be all. Gravity, surface tension and viscosity all play a role when one liquid sinks into another. These forces will be relevant, therefore, for cellular and bacterial growth. As another example, the shape of a drop of ink as it sinks into a container of water is dramatically reminiscent of the shape of a jellyfish and clearly there are evolutionary implications here.

Conclusion

The last section, the last few lines of it in particular, form a natural lead-in into what may lie ahead through new developments in mathematics, in particular in a branch of topology which is being called catastrophe theory. The evidence presented in the various sections of this article, which is only a small sample of the total evidence available, makes it quite clear that much of the form of the natural world and the objects in it is to be understood as a consequence of the physical forces that have shaped these forms. The last section shows the important role topological transformations play in growth and form, so that the subject of topology has clearly a crucial role in theoretical biology. What was missing till recently is a precise way in which this programme of using topology is to be implemented, the mathematical language that is necessary to carry out this programme. The recent developments in catastrophe theory (see Rene Thom, *On Structural Stability and Morphogenesis*, Benjamin, Inc, 1975, also V. Monteiro, *Catastrophe Theory*, SCIENCE TODAY, September 1975, p. 13) may provide the answer and the theorems and the mathematical language and concepts for handling th topological transformations. O essential aspect of these transform tions is that they are often sudd and " catastrophic " — hence, t name given to the theory. Anoth aspect is that often only a few i dependent variables govern the cat trophic transformation of an enti system. These features are illustrat by the suddenness of the change biological transformations — the e vironment may be changing gradual but, suddenly (in terms of natur biological or evolutionary time scales a whole species may be transforme This is, of course, the " catastrophe and may account for why so fe transients are seen. It also is clear relevant for those who search for mis ing links in evolution and is sure responsible for why such a search so arduous because these transien are rapidly traversed by the course evolution, leaving behind few trac or none. The usual mathematics tha is familiar in the physical science and which has been used increasingl in theoretical biology, is the one d differential equations where sma changes in initial data lead to sma effects. Such mathematics is quit inadequate to handle the situation we have been describing where sma changes have large, catastrophic re ponses. The new mathematics c catastrophe theory remedies the short coming and it is for this reason tha there is considerable excitement nov about the prospects for major break throughs in the field. In the year ahead, we may expect to see catas trophe theory play this role as a mor mathematically rigorous treatment o D'Arcy Thompson's consideration with far-reaching implications for ou study of forms in the world around us — why things are the way they are



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ZOOLOGY

How Desert Scorpions Hunt at Night

It appears that the science of seismology and electrophysiology are combined by the desert scorpion (*Paruroctonus mesaensis*) in hunting its prey at night. This is the conclusion of some experiments conducted by Philip H. Brownell at present at the Department of Physiology, Medical School, University of California, San Francisco, and reported in *Science* (**197,** 479, 29 July 1977).

The sand scorpion is a very good hunter and can locate its prey up to 50 cm away in total darkness. Its main food is the burrowing cockroach (*Arenivaga investigata*) which, however, buries itself as soon as it can detect the scorpion's approach. When it is out hunting, the scorpion adopts a characteristic pose with its legs spread out in a circle about five centimetres across. Its range, accuracy and speed of localisation of the prey are such that in three or four orientation movements, lasting about one second each, the scorpion can position itself over its prey. Thereafter, movements of the cockroach provoke a fast digging behaviour from the scorpion that uncovers the prey. Dr. Brownell found that scorpions could locate their prey only when it was in contact with the sand. He, therefore, conjectured that some signal must pass through the sand to indicate the position of the prey relative to the scorpion. He has, in fact, investigated the nature of the signals.

He buried piezo-electric transducers in the sand to see whether small movements of the cockroaches can be transmitted through the sand for any distance. He found that sand can conduct two sorts of waves, comparable on a small scale, to seismic waves. There was a fast compressional (P or pressure) wave that spread out spherically from the disturbance and a slower Rayleigh wave travelling out in a circle on the sand surface.

Having discovered this, he turned to the scorpion to determine whether it is capable of detecting these waves. He found that at the tip of each of the eight walking legs are two types of movement—sensitive receptors, the tarsal hairs that support the leg on the sand and a group of eight slit sensilla (the basitarsal compound slit sensillum) in the cuticle of the last joint in the leg. He managed to insert microelectrodes into both types of sensor and to record their response to a simulated cockroach at various distances. The records showed that the fast wave was detected first by the hairs and then the slow wave was detected by the slit sensillum.

He found that at five centimetres both the hairs and slit receptors actively responded, but as the distance increased the tarsal hairs began to fail. At 10 cm, the hairs did not always respond and at 20 cm only the slit sensillum responded, leading to the conclusion that the surface waves are used to locate the prey at long distances. This was confirmed by making a small hole (250 micrometers) in the cuticle of the slit organ. This altered the scorpion's accuracy, whereas removing the tarsal hairs had no effect. Dr. Brownell concludes that it must be the slower, surface waves detected by the receptors that convey the necessary information. The Rayleigh waves travel at about 40 m per second in loose sand and the scorpion picks up these waves and measures the delay of about 1 microsecond between the widely spaced first and last legs to detect the direction of the prey.

Sand-dwelling scorpion exhumes the burrowing cockroach it has located by sensing compressional and surface waves generated by the prey's movements

CELL BIOLOGY

Programming Genes

Genes that become inactive during cell differentiation can be reactivated, in the absence of cell division, by normal components of oocyte cytoplasm. This is the main conclusion of a research work undertaken by Dr. J. B. Gurdon of the Medical Research Council Laboratory of Molecular Biology, Cambridge, England, who has specialised in research on gene control in eukaryotic cells. In collaboration with Dr. E. M. De Robertis, he has shown in a recent issue of the *Proceedings of the US National Academy of Sciences* (**74,** 2470, June 1977) how genes can be reprogrammed. In fact, they have found that the inactive genes of a mature frog kidney cell can be reprogrammed to become active and behave like egg cell genes if they are transplanted into an immature egg cell.

All cells, being the direct descendants of one egg cell, contain genes that enable them to become any kind of body cell. Most of the genes are normally switched off, and only some are expressed at any stage in a cell's lifetime. One of the principal characteristics of animal development is that genes that become inactive in the course of somatic cell differentiation rarely become active again. An experimental reversal of this stable inactivation would make it possible to investigate the molecular basis of gene control in development.

They transplanted the nuclei of the kidney cells of the frog *Xenopus laevis* into oocytes of the newt *Pleurodeles waltlii* from which the nucleus had been removed. The result was that the oocyte produced frog oocyte proteins and not the proteins characteristic of a kidney cell. The proteins were analysed by two-dimensional gel electrophoresis. They believe, for several reasons, that the activation of frog oocyte specific genes resulted from the translation of mRNAs synthesised by the injected nuclei within the newt oocyte. According to the British biologists the gene expression by *Xenopus* somatic nuclei has been "reprogrammed" by the *Pleurodeles*

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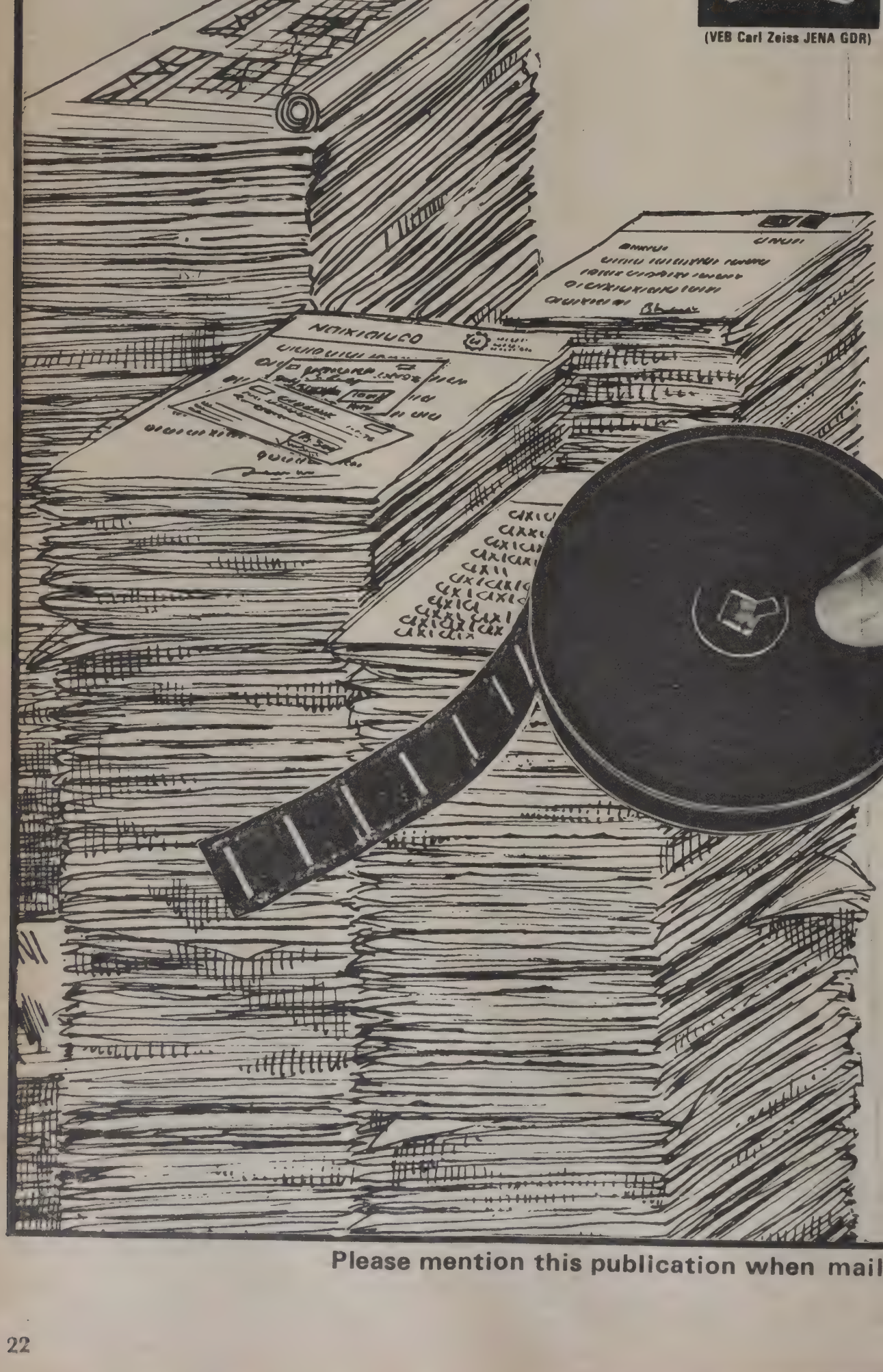

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oocyte cytoplasm, since the proteins produced were frog proteins and not newt proteins. Of great interest is the fact that the expressed genes include some of those which were previously inactive in the somatic cells. An important implication of the results is that the oocyte cytoplasm contains special molecules which switch on the required genes.

PARTICLE PHYSICS

Discovery of a Fifth Quark ?

Exciting discoveries are being made in the field of particle physics in the last few years. The latest one, from the Fermi National Accelerator Laboratory in Batavia, Illinois, USA, (if confirmed) may be the discovery of a single particle of energy 9·5 billion electron volts, the highest mass particle discovered so far. The speculation is that this particle may be made up of the fifth quark that some theoretical physicists have conjectured.

The search for dileptons or pairs of leptons (electrons or muons) in the products of various kinds of collisions between particles and particles and particles and targets has become the pastime of many particle physics groups in recent years. The sixteen physicists from the Columbia University, New York, Fermi Lab and the State University of New York at Stony Brook, New York, have in their experiments, reported in the *Physical Review Letters* (**39,** 252, 1 August 1977), bombarded copper and platinum targets with protons of 400 BeV from the Fermi Lab's synchrotron. They observed a strong enhancement at 9·5 BeV in the mass spectrum of 9,000 dimuon events with a mass $m_{\mu+\mu-}$ greater than 5 BeV. The muons produced were analysed in a double arm magnetic spectrometer system consisting of proportional wire chambers, scintillation counters and gas-filled Cerenkov counters.

The experimenters had not given any interpretation of the results in the published paper. However, the possibility that they had discovered a short-lived particle of mass more than ten times that of the proton which decays into a pair or pairs of muons cannot be ruled out. The large mass also suggests the possibility of a bound state of two or more particles, a baryon molecule or a charmonium molecule. While several interpretations of the event are expected shortly, the original experimenters have at a meeting of the European Physical Society at Budapest urged that they may have discovered evidence for the existence of a fifth quark.

Quarks, theory postulates, are sub-particles from which most of the known subatomic particles are built up. Three years ago, three quarks, called " up, down and strange " (and three corresponding anti-quarks) were enough to explain the properties of all the subatomic particles then known. But the discovery of the psi particles in November 1974 (see SCIENCE TODAY, January 1975, p. 8) changed the picture. Theorists now suggest the existence of at least six quarks to explain the exotic behaviour of the newly discovered particles. The existence of the fourth quark, " charmed quark ", was confirmed last year (see SCIENCE TODAY, September 1976, p. 24). Once the charmed quark was in the picture, symmetry principles and other considerations led to the opening for a fifth and sixth quark, the " top " and " bottom ", and rather whimsically designated the " truth " and " beauty ". Though the evidence for the fifth quark is at best secondary, the group led by L. M. Lederman of Columbia University feels that its data fit in well with the interpretation that the enhancement it had observed is a particle made of a " bottom " (beauty) quark and a " bottom " anti-quark. They have designated the assumed particle upsilon.

ASTROPHYSICS

More Light on X-ray Pulsars

X-ray astronomy, more than a decade old, has established itself, in its own right, as a separate branch of modern astronomy. But, there are still many peculiar phenomena for which explanations are being continuously sought. One of these is X-ray pulsars, emission of X-radiation in periodic pulses. The first object in this category was discovered about six years ago.

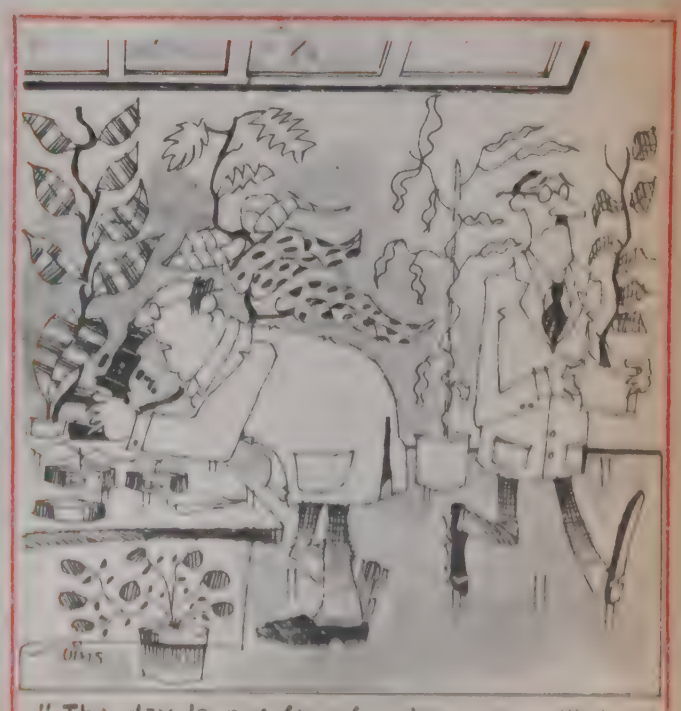
Hercules X-1 has proved to be one of the most enigmatic of more than a dozen pulsing X-ray stars so far discovered. It emits a pulse of X-rays every 1·24 seconds, but the pulse period itself varies in a sinusoidal manner every 1·7 days. What is more, it stops emitting radiation altogether for nine hours in every 1·7 day period. The consensus among astronomers is that Hercules X-1 is a neutron star and that it has a very strong magnetic field of the order of a 1,000,000,000,000 (trillion) gauss. Its companion is HZ Herculis, a star already well known for variable optical brightness. The matter in the outer layers of HZ Herculis are stripped off and accreted by the neutron star.

The mechanism of emission of X-rays is suspected to be synchrotron radiation, the type of radiation emitted by charged particles accelerating in a strong magnetic field. The highly ionised material from HZ Herculis is accelerated in the magnetic field of the neutron star, Hercules X-1, as it travels towards the magnetic poles, releasing much of its energy in the form of X-rays. If the magnetic axis and the axis of rotation do not coincide, then the X-radiation will be pulsed with the star's rotation period of 1·24 seconds. Possibly, Hercules X-1 spends nine hours of its 1·7 day period behind HZ Herculis and is thus hidden from the Earth's view.

Some support to the idea that the X-rays may arise from streams of ions from the normal star accelerating in the collapsed star's strong magnetic field has now been provided by a team of astronomers from the Blackett Laboratory, Imperial College, London in a letter to *Nature* (**268,** 508, 11 August 1977).

The team consisting of M. J. Coe, A. R. Engel, J. J. Quenby and C. S. Dyer had a scintillation telescope covering the energy range 26 keV to 1·2 MeV on board the United Kingdom satellite, Ariel 5. They observed a significant X-ray flux excess in the 56–94 keV band with a characteristic line feature at 64 keV. On the assumption that the line is due to synchrotron radiation from the poles of a neutron star, they obtain a value for the magnetic field of the star of the order of 7,000,000,000,000 gauss, both on the classical theory and relativistic quantum mechanical treatment. This value is in agreement with theoretical assumptions suggesting that synchrotron radiation indeed may produce the X-rays. The Imperial College team concludes that if its explanation of the observations is correct, a new way of exploring pulsar magnetic fields has opened up.

K. A. NEELAKANTAN



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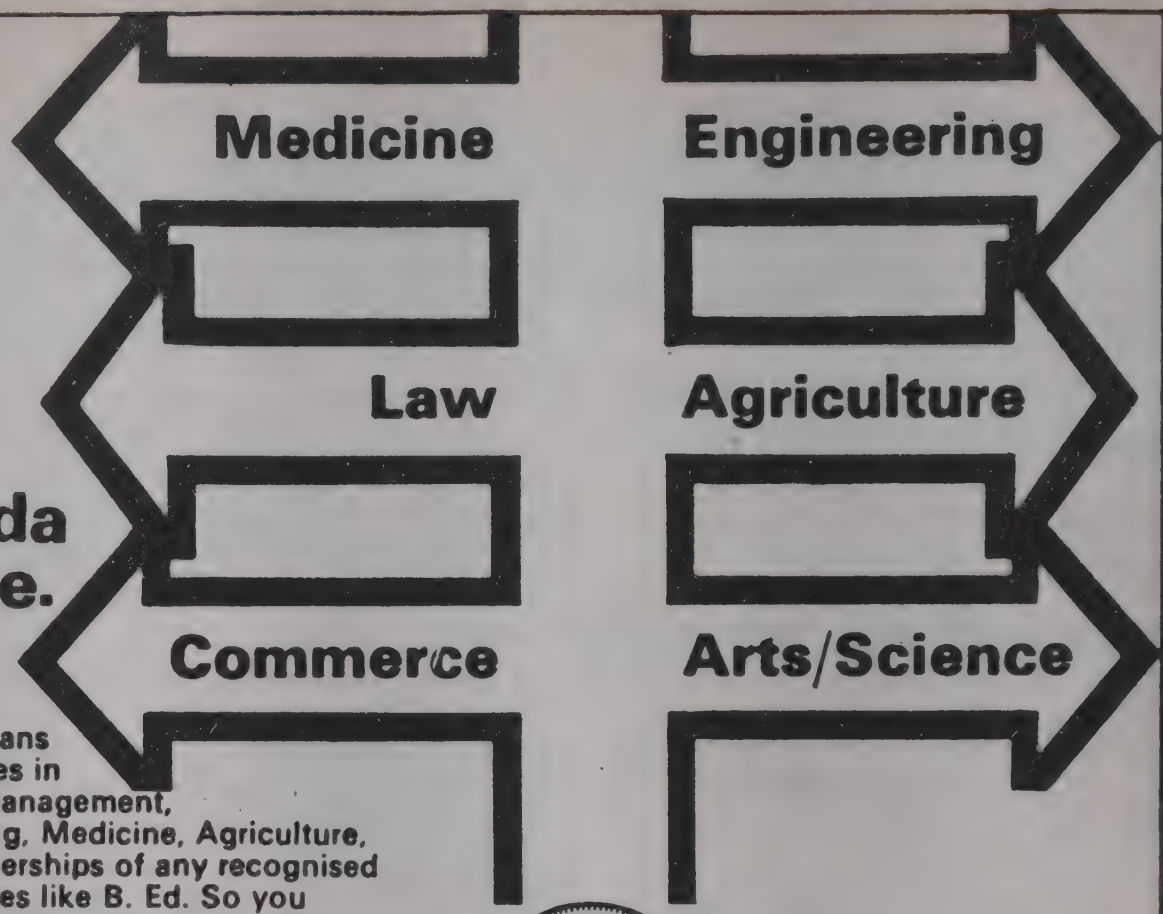

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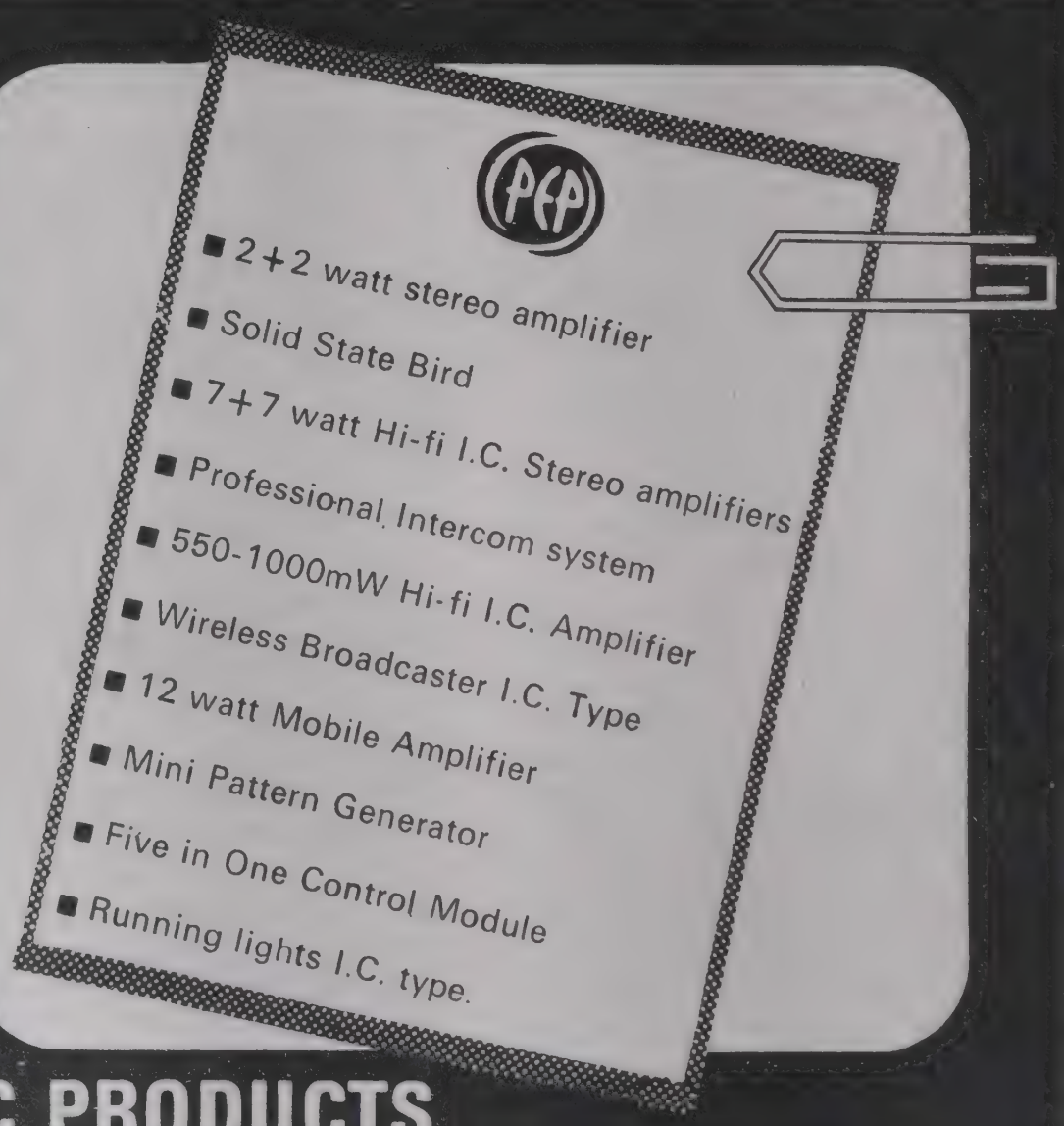

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Barna leaves, flower and fruit

Padekar

let's get to know our trees!

7 MORE DECIDUOUS FOREST TREES

During this time of the year, the monsoon shows signs of receding from a large part of the Indian peninsula, after having contributed to the growth and regeneration of innumerable plant species all over the land. This is the time when the richness of the woodlands is at its peak, for the luxuriant plant growth, especially of the titans of the forest, the trees, has benefited the largest number of small life around. The grubs of insects have fed and fattened on the foliage, as did other creeping and crawling creatures; reptiles and birds have found shelter, safety and food in the leafy bowers; animals, too, are assured of a rich fodder for perhaps a few months to come before the massive leaf-fall which commences in winter and continues into early summer.

An impressive deciduous tree familiar to many of us as an ornamental garden or roadside tree is the **queen's flower** or **jarul** in Hindi (*Lagerstroemia speciosa*). The jarul is a denizen of the forests of south India as well as eastern India spreading eastwards through Burma into China and Malaysia. In forest regions where the soil is damp, as in the vicinity of streams, the tree reaches good proportions and rises to over 20 metres in height, whereas many specimens in cities are smaller in size.

The jarul is at its most beautiful between April and July when its flowers, which are borne on the end branches in panicles, thrust outwards. Though a deciduous tree, it is never really completely leafless since the leaf-shedding of the cold season and early summer is quickly replaced by new leaves; the old leaves turn yellow and then red just before they fall off, and this, too, adds a touch of colour to the tree. Each smooth and shining leaf is about the size of one's outstretched hand and many leaves arise from thick stalks which reach out and droop slightly. Its mauve and pink flowers, massed together in clusters around a stout stalk, are the most impressive and delightful. Many flowering branches push upwards at the same time in majestic floral explosions. The flowers at the base of an inflorescence turn a paler shade as they grow older and one can observe a transition of colours along the branch — the younger flowers higher up in bright hues varying from mauve to purple and pink, and those at the top in green buds waiting to open.

The jarul flower is about 5 cm in diameter and is symmetrical; the green calyx is broadly tubular, almost cup-like with five or six pointed projections which persist even after the fruit develops; the petals, six in number, arise from a small disc from slender, narrow bases (called claws) and spread out radially; each petal is rounded at the apex, wavy and crinkled like crepe paper. The true beauty of the flowers comes out best when they are back-lighted by the Sun low in the sky — the soothing pastel hues then stand out, imposing yet not aggressive.

Jarul fruits are round capsules with six compartments in each. These remain on the tree for a very long time, and it is usual to see old fruits of the previous year still clinging to the branches. Each capsule splits open longitudinally into its six constituent loculi discharging many small, thin seeds, each of which is winged at the apex.

The jarul is an important timber tree, second in importance only to teak; the reddish, walnut-coloured wood, being hard, strong and elastic, is used for making boats, carts, planking and the like. The smooth, pale-coloured bark is known in indigenous medicine for its stimulant and fever-reducing effects; the bark leaves and fruits contain tannins. In the Philippines, a decoction of the leaves, known

Queen's flower

Pad

by the name *banaba*, has been used to treat diabetes; interestingly, the lowering of blood sugar levels by this decoction has been experimentally substantiated and reported in scientific literature. The leaves are also purgative and diuretic, while the seeds are believed to be narcotic.

Nandi tree. Inset shows branch with leaves and fruits (photos by S. R. Nayak)

Among the ten odd species of the genus *Lagerstroemia* found in India, another tree one sometimes encounters, growing side by side with other deciduous trees in the forest, is the **nandi** tree (*Lagerstroemia lanceolata*). It has been mentioned by this name (*nandi*) in Valmiki's *Ramayana*. Quite unlike the jarul, the nandi lacks colourful showy flowers; its flowers are small and white, disposed in clusters on the extreme ends of leafy branches and often escape notice, especially in tall trees whose canopies are obscured by other trees. Like many other *Lagerstroemiae*, its trunk is smooth and light greyish-brown in colour with thin, long strips of bark peeling off. The nandi flowers with the onset of the rains, and shortly thereafter large numbers of small bullet-shaped capsules develop. Its leaves are somewhat smaller than those of the queen's flower, are rough in texture and dull green; they are often collected to be used as green manure. Nandi wood is strong and elastic and is used for building and other constructional work.

A rather unusual deciduous tree with a wide distribution throughout our country is the **chalta** (*Dillenia pentagyna*). What strikes one on seeing this rather large tree with pale, smooth bark is the immense size of its leaves. Each leaf when full grown is almost one metre or more in length, and about a third as broad; it is pointed and the margins are serrated like the blade of a saw. The leaf is rough and stiff, linear and elliptical in shape, with prominent nerves running from the central rib to end at the tips of the saw-like edges. The leaves tend to be bunched together near the terminal portions of the branches. A sure sign that the chalta grows in a forest is to find its large leaves on the ground, especially in early summer; the tell-tale shape and size of the leaves gives away its presence, for the tree is not too numerous and it is generally not common to find large pure strands of chaltas in a forest; it mostly grows in association with other trees.

Between March and May, the tree is relatively bare, with some new leaves emerging, when the five-petalled, yellow flowers appear in fascicles on the leafless old branches. The chalta flower is about 5 cm across, possesses thick ovate sepals, yellow petals with crinkled margins, and a central cluster of many yellow stamens. The chalta fruits rather profusely in May and June; the fruit each the size of a table-tennis ba are edible both raw and cooked, an have an acid-sweet taste. Both th light green raw fruits as well as th orange-yellow ripe ones are a grea favourite with monkeys and deer. A peculiar feature of the fruit is tha each juicy capsule is enclosed by th fleshy sepals of the calyx which grow and merge with the fruit; it therefor appears to be overlain by broa fleshy ribs; the four or five seeds i each fruit are disseminated throug animals which eat the fruit.

The chalta has some economic use locally; the hard, purplish-red heart wood is used for making house posts rafters and the like, and sometimes fo charcoal; village folk use the large leaves as platters and thatching mater ial, sometimes even as a makeshif sandpaper for polishing; the bark provides a rough fibre for cordage.

The fruit tree mentioned by Val miki in Sanskrit as *charitra* or *bhavya* i believed to be another species, *Dillenia indica*, with smaller leaves, large white flowers and larger fruits. Its fruit juice mixed with water and sugar is used as a cooling beverage in fevers and cough. *D. indica* fruits are laxative and may cause diarrhoea if eaten in excess. In animal experiments, alcoholic extracts of the leaves are reported to depress the nervous system in mice.

The al (morinda). Note the fruit with " eyes " (photo by S. R. Nayak)

A tree often planted near temples, shrines and tombs, and held to be sacred, is the **barna** (*Crataeva nurvala*). The tree, known in Sanskrit as *varuna* or *triparni*, has been referred to by both Valmiki and Kalidasa. Small to moderate-sized, not usually exceeding 10 to 12 metres in height, its leaves are trifoliate being composed of three leaflets borne on

the end of a single stalk; they are shed during the winter and by February the tree is bare; new leaves sprout about a month later. At this time the flowers bloom in loose clusters all over the tree; in some parts of South India the flowering season is from November to January. Barna flowers, unlike most other flowers, have four sepals, and four petals — generally white in colour but quickly turning yellow. A singular feature of the flowers is the large number (about 20 to 25) of stamens, longer than the petals, jutting out of it and surrounding the female part which is itself composed of the ovary borne on the end of a thin stalk as long as the stamens. This ovary (and its stalk) is called a gynophore, and when the fruit develops later towards the close of the rainy season, it is attached to this stalk which has developed from the gynophore. The barna fruit is a round woody berry containing many seeds embedded in a yellow pulp enclosed in a fairly hard shell; the raw green fruit changes to a dark red colour on ripening much in the same way as an apple does.

The sacred barna, also found in the wild state throughout India, is reputed to possess medicinal properties. The leaves are irritant when crushed and rubbed on the skin; this rubefacient action makes it useful (externally) in rheumatism. Internally, the leaves are considered a febrifuge; and many parts of the plant are administered to improve the tone of the urinary bladder and aid in removing urinary stones. Extracts prepared from the bark have shown anti-inflammatory effects in experiments on laboratory animals. The fruit pulp mixed with mortar is known to make a strong cement. Barna wood, pale yellow and close-grained, is employed for making small utility items like combs, matchsticks and the like.

A very well-known soft drink of indigenous origin is *phalsa*, a rich purple coloured acid-sweet beverage made from the small ripe fruits of a plant also known as **phalsa** (*Grewia asiatica*). While this small tree may be familiar to some owing to its wide cultivation, especially in North India, a less familiar member of this genus, the **dhaman** (*Grewia tiliaefolia*), grows rather extensively in the deciduous forests, practically throughout our country.

The dhaman is a medium-sized tree growing to about 10 metres or so in height. During the rains many saplings of the plant may be seen to spring up here and there — identifiable more from the characteristic shape of the leaves than from other features. The leaves are about as large as one's palm (often larger in small saplings) and roughly heart-shaped with one side of each leaf appearing somewhat bigger than the other, thus making it seem slightly curved. Young leaves are a dull red in colour and very furry to feel.

Small, yellowish-white flowers appear in threes and fours in the axils of the leaves from May to August, much after the summer leaf-fall, and the pea-sized fruits develop from June to October. The fruits turn a deep red and then almost black when they ripen. Like the phalsa, dhaman fruits are edible, the pulp being sour and sweet to taste though not as flavoury as those of the phalsa.

Dhaman leaves are used as fodder for livestock. A peculiar feature of the bark (which yields an excellent fibre for rustic ropes) is that it is rich in mucilage which can be extracted by crushing it; this is sometimes used by village women to wash their hair. An interesting use shown to me by a tribal man was the application of the

(contd. next page)

" Some game sanctuary you've brought me to ! Not an animal worth the name in sight. "

IN LIGHTER MOMENTS

When the American physicist and rocket pioneer Robert Hutchings Goddard (1882—1945), shortly after the First World War, expressed the hope that it would be possible in the near future " to send an unmanned rocket to the Moon " he was badly shocked to find that, apart from some well-meaning personalities of the scientific world, almost the entire press let him down by ridiculing his expectation. However, he got his own back by not calling a press conference in 1926 when he succeeded in firing the first modern rocket — the forerunner of today's spacecraft.

* * *

The American astronomer, Simon Newcomb (1855 — 1909) dared any one to demonstrate in 1906 that " a heavier-than-air machine can ever fly for more than a short distance " — although the Wright brothers had been doing this since 1903. Still later, in the mid-1930s, yet another eminent astronomer of the USA, Forest Ray Moulton (1872—1952), was equally pessimistic when, dealing with spaceships, he wrote : " There is not in sight any source of energy that would be a fair start toward that which would be necessary to get us beyond the gravitational control of the Earth."

* * *

Until the mid-eighteenth century the conditions of even the biggest public hospitals in England were such that, in spite of being free, people were scared of getting admitted there. At St. Bartholomew's, indoor patients were required to deposit in advance 19sh. 6d. as burial fee, to be refunded in case they recovered.

* * *

The number of charlatans and frauds has been greatest amongst chemists (alchemists) and physicians. In 1738, one Mrs. Joanna Stephens made a public announcement that she possessed a sure remedy for stone trouble and could disclose it for £5,000. Collections were launched to raise the fund by a committee of bishops and dukes. Parliament also made a big contribution. When the necessary amount was collected, Mrs. Stephens' secret remedy was announced in the *London Gazette:* " The medicines are a powder, a decoction and pills. The powder consists of egg shells and snails, both calcined. Decoction is made by boiling some herbs (with a base made of soap, Swine's cresses burned to blackness, and honey) in water. The pills are snails calcined, wild carrot seeds, burdock seeds, ashen hays, hips and haws ; all burned to blackness, Alicante soap and honey." Needless to add, it was all bunkum.

* * *

How did the stethoscope originate? Its inventor, Rene Laennec, says : " Taking a sheaf of paper I rolled it into a very tight roll, one end of which I placed over the pericardial region, whilst I put my ear to the other. I was both surprised and gratified at being able to hear the beating of the heart with much greater clearness . . . than I had ever done before."

S. N. MUNSHI

The large leaves and the darkened ripe fruits of the dhaman

Padekar

bark mucilage liberally to the skin when one comes in contact with the severely irritating hairs of the cow-itch pods (*Mucuna pruriens*); its soothing action became apparent within a few minutes.

The hardness and elasticity of the wood makes it suitable for making cart-axles, masts, oars and bent frames for carriages, etc. Bows, too, have been made from dhaman and related trees. Quite appropriately, the dhaman is known in Sanskrit as *dhanuvriksha* (literally, the bow tree).

The **jhingan** or **kimul** (*Lannea coromandelica*), a large deciduous tree with a wide distribution in India, including the Andamans, presents a striking contrast in appearance at two different seasons: during the rains it sports a dense canopy of big oddly pinnate compound leaves and gives the semblance of a truly evergreen tree, whereas in summer, bereft of foliage, it is reduced to a mere black-barked scrawny skeleton.

The small flowers, massed together in fascicles at the ends of the branches, bloom from February to April when the tree is bare. Male and female flowers occur separately on different stalks but on the same tree. The small petals are yellowish-white or purplish. When the oblong, 2 cm long, rather kidney-shaped compressed fruits develop, they hang from the stalks at the farthest ends of the branches — looking like strings of beads hanging from outstretched fingers. The fruit is greenish-grey when raw but becomes dark red when it ripens. Though the scanty pulp is not palatable, and even acrid when raw, the fruits are eaten by birds and monkeys which thus help in dispersal of the seeds.

From the economic standpoint the jhingan tree has some uses: the leaves serve as fodder for livestock; the bark has been used for tanning and dyeing cottons a brown colour; a gum exuding from the incised bark, called jhingan gum, is used in the preparation of inks, for calico printing, in confectionery and making varnishes, and as a flocculating agent. The bark also yields a strong fibre, and its uses in native medicine include application (as a lotion) to bruises, sores, etc. The gum is also believed to be useful in asthma.

At one time, prior to the advent of synthetic dyes, a red dye used to be extracted, particular to dye wool and silk, from the ro bark of the **al** (or **aak**) tree (*Morin* species). Two species commonly e countered are: *M. tinctaria* with hai leaves, a deciduous forest tree, an *M. citrifolia*, with smooth leaves, ofte grown on the roadside in some citie

M. tinctaria is a medium-sized tre with a dark, deeply cracked, cork bark. In the field, it can be recognise from the entire, hairy leaves whic are disposed in pairs — one of eac pair being opposite to the other, an especially during the rains from i characteristic fleshy fruits. It bea small white flowers, with tubula corollae from each of which five pet lobes radiate; the flowers arise from globose head which later grows an enclosing the seeds from each flowe becomes the fleshy fruit known a syncarpium. The fruit, about the siz of a child's fist, appears roughl angled and globular with "eyes peeping out from polygonal marking on the fruit (see p. 26). The fruits ar not generally eaten except as a famin food.

Al wood is pale-coloured, easil worked and durable, and is used fo making plates and dishes. The leave make good cattle fodder. Though no much used in indigenous medicine some investigators report that th blood pressure of laboratory animal is lowered by water extracts of it roots.

A walk in the woods is very muc like passing through a large banque hall — so much to sample and s many things to taste in the shor while one is there. After satiating our selves while the going is good, shoul we be thoughtlessly clearing th tables unmindful of yet others wh may pass that way and sample the fare?

S. R. AMLADI

(Left) Chalta

Padekar

Padekar

(Right) Jhingan. The former botanical name *Odina wodier* was derived from the Malayalam *odiya maram* and the

ON BREEDING CROCODILES

M. V. SUBBA RAO

In January this year, a 50 cm suitcase made of crocodile skin was sold for Rs. 12,000 in London. The skin had come from an estuarine or saltwater crocodile, probably killed for that very purpose; it had probably come from India, which would mean one less of this fast dwindling animal species.

It would be a pity if crocodiles were to disappear from the earth. They began life on this planet 140 million years before man; today their habitat, already shrinking, is confined to a few pockets on the earth. Crocodiles, alligators and caimans — all belong to the same family Crocodylidae or Loricata. Crocodiles are distinguished by their narrow snouts with a notch near the front on both sides into which fit the two large lower teeth; these can be seen when the jaws are closed. The Indian 'gharial' with a very slender snout is a close relative. Alligators, which belong mostly to the Americas, have broader snouts and their large lower teeth fit into sockets inside the upper jaw. Caimans, which are distributed only in the South American continent, have a more oval, blunt and triangular snout.

In all, there are about 22 species of crocodiles living on the earth; of these, only three are found in India and all three are on the endangered list now. These are the *Gavialis gangeticus*, commonly known as the gharial (also gavial), *Crocodylus porosus* or the saltwater crocodile, and *C. palustris* which has the common name mugger or marsh crocodile. Basically a fish-eater, the gharial (the name comes from the *ghara* or the earthen pot-like structure at the tip of the male animal's snout) is a timid animal with a pair of greenish cat-like eyes and an enormously elongated snout; both the upper and lower jaws are studded with sharp, stout, close-set teeth. An adult gharial may grow to nine metres in length — the longest amongst all living crocodiles.

The mugger, too, is a timid animal with gaping jaws and is known to scamper for shelter at the sight of man. Mainly an inhabitant of marshes (hence the common name 'marsh crocodile'), it is the smallest of the three Indian crocodiles. The saltwater (or estuarine) crocodile can grow up to six metres in length and is not a timid animal. The species is easily recognised by a prominent ridge in front of each eye.

We have said crocodiles are a dwindling species in India. The chief reason for the depletion is perhaps the high price their skins fetch in countries abroad. Two-and-a-half centimetres of belly skin is priced at something like Rs. 40, which means a 3·6 metre long crocodile can easily fetch about Rs. 900 — a fortune to a poor fisherman or a poacher. Besides poaching, crocodiles are also killed in many places because, being carnivorous, they are apt to prey on waterfowl and cattle. Occasionally, a member of the larger species may eat a human being or two, but this happens so infrequently that it would be wrong to regard crocodiles as man-eaters. Possibly the mistaken belief had arisen after fishermen had cut open killed crocodiles and discovered human remains in the stomach; in all likelihood, the crocodile had eaten a corpse thrown into the river.

Sometimes crocodiles are killed by fishermen when they get caught in their fishing nets. In 1967, when crocodiles were found to eat the commercial riverine fish in the Sirsi reservoir, the State government issued a contract for all the crocodiles in the reservoir to be killed.

This is a pity. Crocodiles usually feed on big predatory fishes which in turn prey on smaller commercially valuable species. Thus, they are actually helpful to fisheries and do not deplete fish populations as popularly believed. Indiscriminate slaughter of the crocodile has in fact caused ecological imbalances in several parts of the world. For instance, the disappearance of the Nile crocodile (*C. niloticus*) from parts of Africa has resulted in an overabundance of the catfish *Clarias* which in turn has greatly depleted the supply of fishes good for human consumption.

Several countries including India have, by legislation, tried to save the crocodile. In India, both the mugger and the gharial were declared protected species in 1958. Killing, trading, exporting or possessing of crocodiles has been banned under the Wildlife Protection Act of 1972. However, it has come to be recognised that if the original balance is to be restored, crocodiles must be bred and raised on farms. But how does one go about this stupendous task?

The answer was a project started in late 1975 with UN assistance for restocking suitable stretches of rivers, tidal mangrove swamps and reservoirs with Indian species of crocodiles. Today, besides two model sanctuaries in Orissa and Andhra Pradesh, crocodile farming is also afoot at UP, Rajasthan, Tamil Nadu, Gujarat and Kerala.

Fig. 1 (Top) A female adult gharial

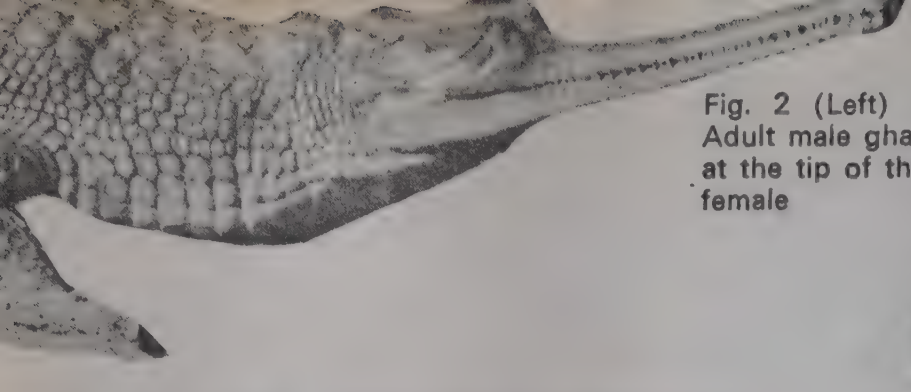
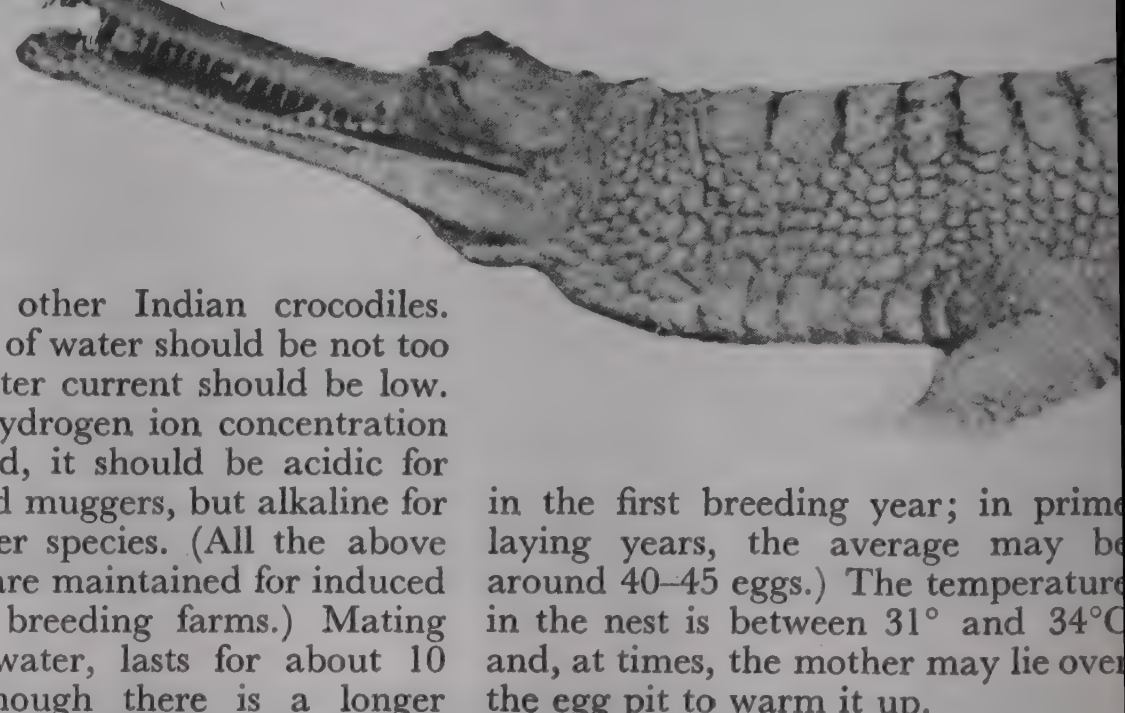


Fig. 2 (Left) Adult female gharial. (Below) Adult male gharial. Note the pot-like structure at the tip of the snout which is absent in the female



In this article, we shall talk about what we have learnt from our work over the past two years at the farms set up in Orissa. There is a significant reason behind our choosing Orissa as a model site: Orissa happens to be the only State in India which has all the three Indian species.

Crocodile farming

There are two types of crocodile farming practised all over the world. One is battery farming, the other, free range management.

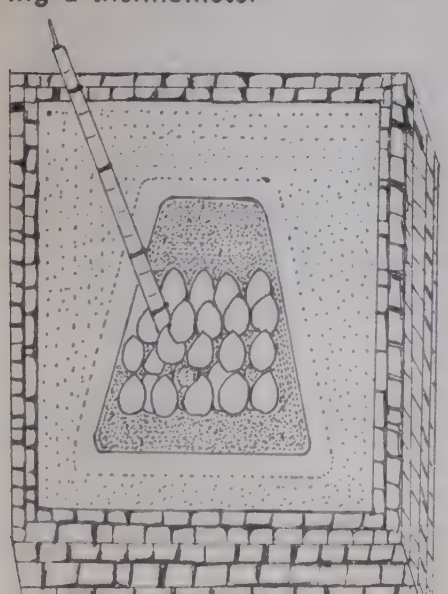
Before coming to the subject of artificial breeding, a brief note should be made about the life-cycle and mating habits of these animals. Crocodiles mature within three to four years after they are born. Mating takes place from the fourth year onwards — during winter (December to February). The mating behaviour is influenced by several external factors. The depth of water should be about nine metres for gharials and two metres for other Indian crocodiles. The colour of water should be not too muddy, water current should be low. As far as hydrogen ion concentration is concerned, it should be acidic for gharials and muggers, but alkaline for the saltwater species. (All the above conditions are maintained for induced mating in breeding farms.) Mating occurs in water, lasts for about 10 minutes, though there is a longer preceding courtship in which the animals rub their muzzles against each other.

The sexes can be distinguished externally only in the gharial in which the males, during the reproductive period, have a bulbous knob at the tip of the muzzle (Fig. 2). The gharial's nest is merely a hole in the ground dug at night by the female with her hind feet. According to th size of the female, she lays 20–90 eg only once in a year. She covers th hole to ground level and slides bac to the water. The female is extreme protective about her eggs and wi attack any intruder. (In the case muggers, there may be only 7–8 eg in the first breeding year; in prime laying years, the average may b around 40–45 eggs.) The temperature in the nest is between 31° and 34°C and, at times, the mother may lie over the egg pit to warm it up.

As the hatchlings emerge, they make periodically short, barely audible grunts which are signals for the mother to pick them up from the ground — with her front teeth and jaw — and take them to the water. Unlike birds or hens, mother crocodiles do not help their young find food. Immediately after hatching, the young ones are about 30 to 35 cm long and

Fig. 3 (Above) Gharial hatchery. (Below) Diagram of the moist sand-filled artificial incubator. The bamboo pole is used for introducing a thermometer

Fig. 4 (Below) Primary gharial pool. There are 10 pools completely covered by a wire mesh. "Second-year pools" (not shown) have larger dimensions. Photograph above shows one side of the pools under construction



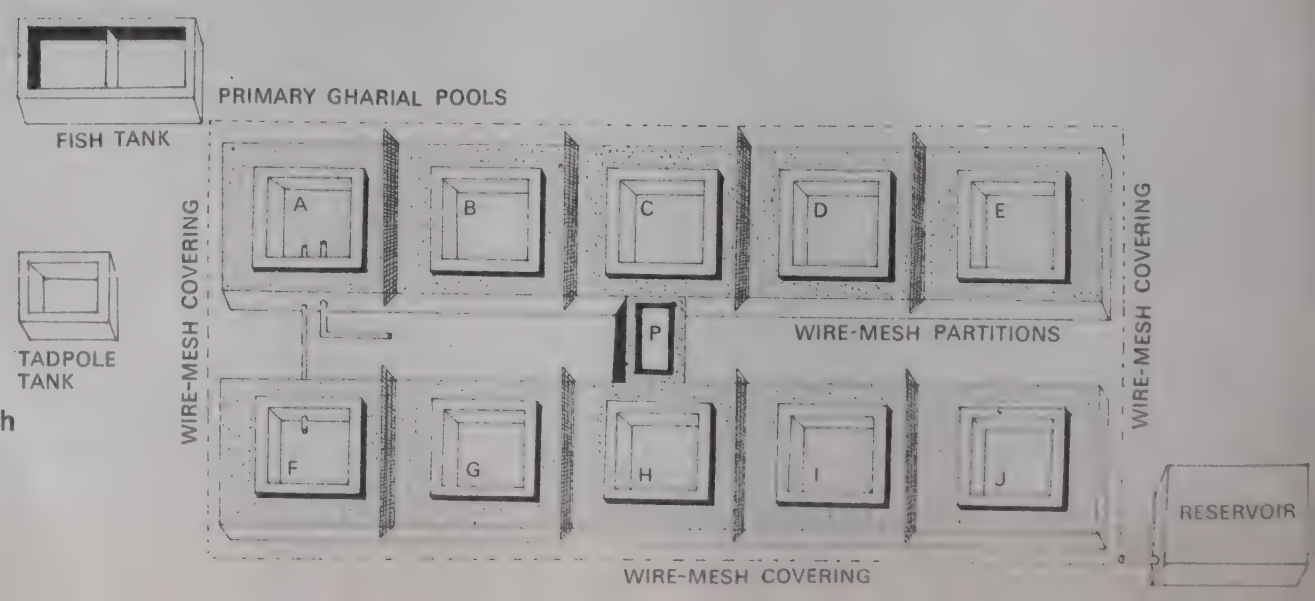


TABLE 1: DISTRIBUTION OF GHARIALS IN THE WILD AND IN CAPTIVITY

In the wild (estimated number) in India	
Girwa river (UP)	22
Chambal river (UP, MP, Rajasthan)	50
Assam rivers	10
MP rivers (other than Chambal)	10
Gandak and Kosi rivers (Bihar)	6
Ramganga river (UP)	4
Mahanadi river (Orissa : 2 males, 2 females)	4
Total	106
In the wild (estimated number) in Nepal	
Kosi river	20
Narayani river	17
Karnali river	8
Babai river	6
Total	51
In the wild (estimated number) in Pakistan	
All rivers	20
In captivity	
Indian zoos	22 (10 males, 12 females)
International zoos	15 (sex distribution not known)

[Source of information: *Zoo Yearbook, Newsletters,* Madras Crocodile Bank, and personal correspondence, etc.]

weigh between 60 & 90 grams. Growth is very rapid in the early days — 6·5 to 7·5 cm per month — though later the growth rate slows down.

The first two years after birth is the most vulnerable period in a crocodile's life. The predators — monitor lizards, wild dogs, cats and birds of prey — may attack during and after hatching. Also, young crocs caught in fishermen's nets are invariably killed.

Most of the information available on the longevity of crocodiles has been gained from observation of animals in captivity. The life-span of a crocodile in captivity seldom exceeds 40 years, but statistics on the growth of the Nile crocodile suggests, however, that those who have attained lengths of six metres are probably more than 100 years old.

Coming back to farming, how are the eggs collected? The first step is to keep a watch on the egg-laying sites (with the help of fishermen and tribals). Mating in gharials generally takes place in January–February, and the eggs are laid by March–April and these hatch in June–July. After a nest has been located, the eggs are collected carefully by hand and kept in ventilated wooden boxes filled with damp nest earth after marking the top of each egg with Indian ink. If the egg is turned or jarred, the delicate embryo is likely to die. Care is taken to collect them during the cool part of the day as a drastic temperature change would be harmful. (In Orissa this sometimes poses a problem as summer shade temperatures are as high as 46° to 47°C. Large natural sand banks, however, maintain the required temperature even on hot days.)

After collection, the eggs are housed in a specially constructed hatchery fully covered by wire (Fig. 3). The only access to the enclosure is through a trap-door on the roof. The whole structure is covered by a thatching to provide shade. Eggs are placed in a hole in a cubic metre of slightly moistened sand (about seven per cent water content by weight) held in place by side-walls made of half bricks; this allows passage of air causing an evaporative cooling effect as in an earthenware water pot. The degree of cooling can be controlled by the amount of water added to the nest mound daily. The gharial eggs are maintained in three layers at the centre of the hole — each of 22, 10 and 8 eggs, respectively. A thermometer introduced through a thin bamboo pole records the temperature which is maintained at a steady 30° ± 0·5°C by sprinkling the sand with six to eight litres of water every day during the summer — the water regime has been worked out to keep the eggs slightly on the cool side.

The young ones, immediately after hatching, are kept in the "first-year pools" (Fig. 5) for about one year. The first-year pools have dimensions of 2·13 m × 2·28 m, with a sloping depth from the pool edge to a maximum of 0·3 m. Each pool, separated by a 0·3 metre high wire mesh, is surrounded by clean river sand containing living *Salix* for the young gharials to bask in the morning and evening Sun. Large-leaved plants such as *Cycas* are allowed to overhang the pool for additional cover. In winter the roof is covered with polythene as protection against cold. A fast-growing creeper (*Antigonium*) and palm-leaves (*Borossus*) are also tied to the roof in an irregular pattern to provide a sunshine mosaic. Each set of five pools is connected to another set by a cemented 2·5 cm deep path which contains dilute potassium permanganate solution. Any person wishing to enter must step into the solution first. The permanganate acts as a disinfectant. The ten gharial pools are covered by a wire mesh. There are tanks for fish and tadpoles, for the baby gharials to feed on. Baby gharials do not take food for about five days after emerging from the eggs; their nutrition comes from the absorbed yolk-sacs. About 250 to 350 scaleless live fish (not generally consumed by man), 2·5 to 3·5 cm in length, are let into the tank every day. When feeding starts, baby gharials are found to be initially clumsy at catching their prey.

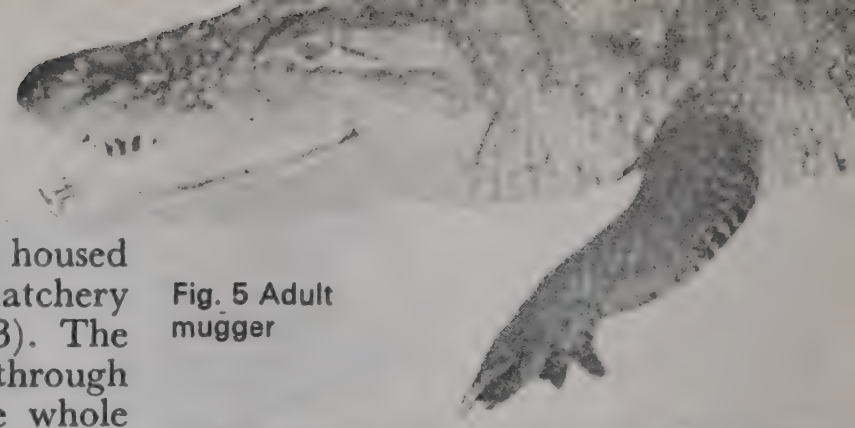
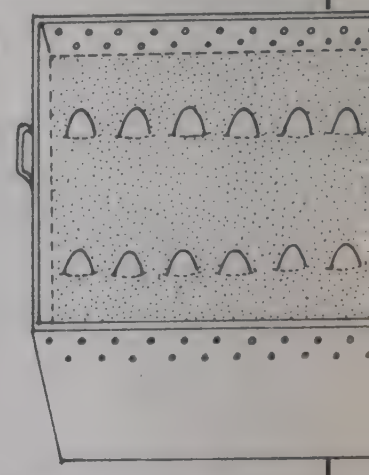


Fig. 5 Adult mugger

The problem of transporting eggs



For battery-breeding, eggs need to be transported to the hatcheries from nests discovered along marshes or river banks, some located long distances away from the breeding farms. This requires expert handling. The ventilated wooden box (shown above) is the best possible arrangement at present. Measuring 50 × 40 × 30 cm, these are fitted with handles for carrying by 2 to 4 persons. Each box can hold 12 eggs, packed in moist nest earth.

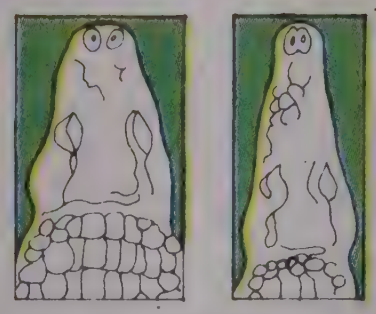
Yet the prized eggs do get destroyed. For instance, last year, 236 eggs were collected from the Narayani river in Nepal, some from fishermen who were carrying them in their boats to take home and make omelettes. The eggs were brought to Patna by Land Rover, then to Cuttack by rail and then another 190 km to Tikerpara by Orissa State Forest Jeep. Less than a hundred survived (that is, 60 per cent mortality). The mortality rate depends mainly upon the size of the egg, the movement of the egg during transit and also the hatchery conditions during the incubation period. Interestingly, Dr. H. R. Bustard brought 10 one-month-old baby gharials from Lucknow to Bhubaneswar by air in a single small air-bag and all 10 are growing healthily at the Tikerpara gharial pool.

Below: The author (left) with Dr. H. R. Bustard, FAO expert on crocodiles and sea turtles

SOME NON-INDIAN CROCODILES

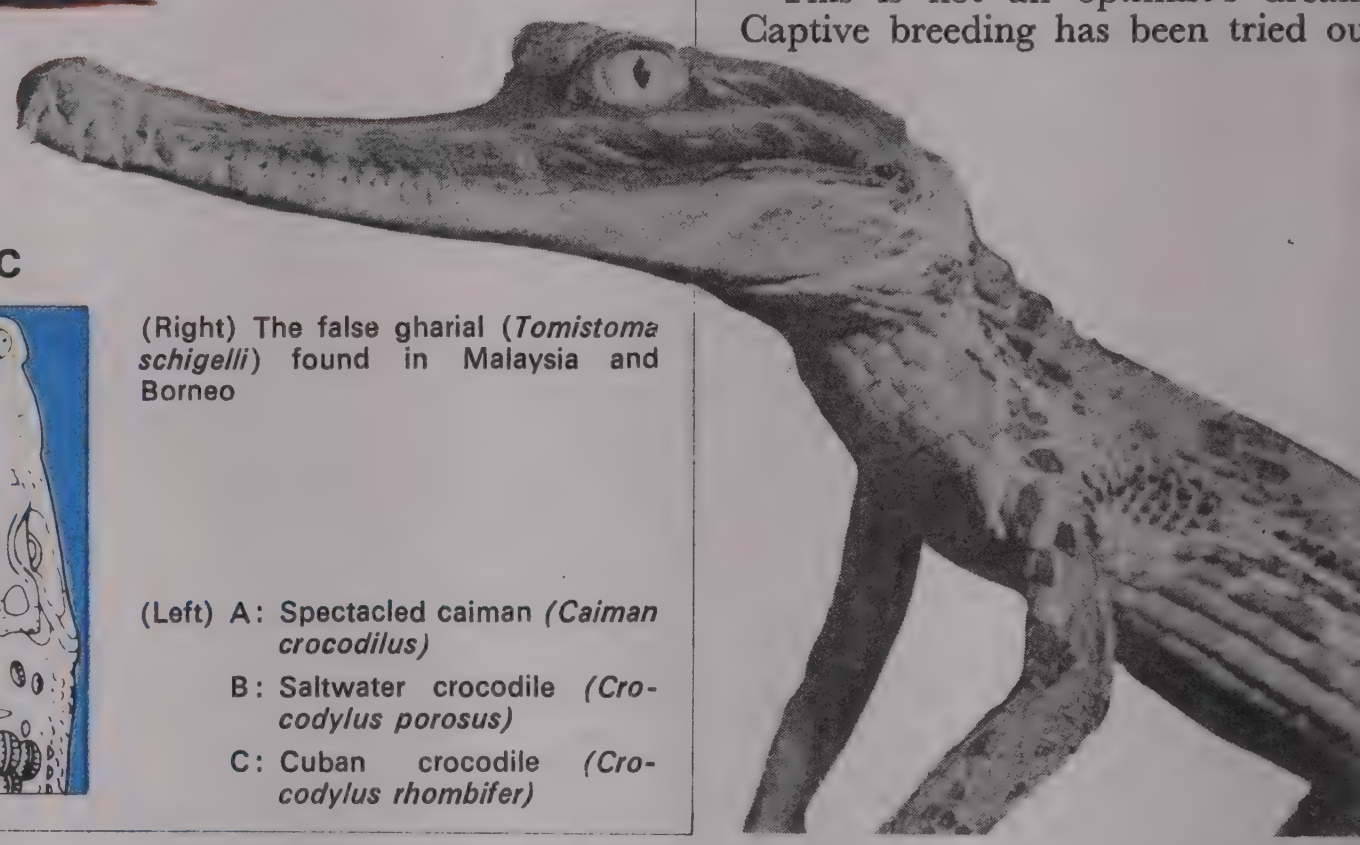
(Below) American crocodile *(Crocodylus acutus)*

(Left) American alligator *(Alligator mississipiensis)*

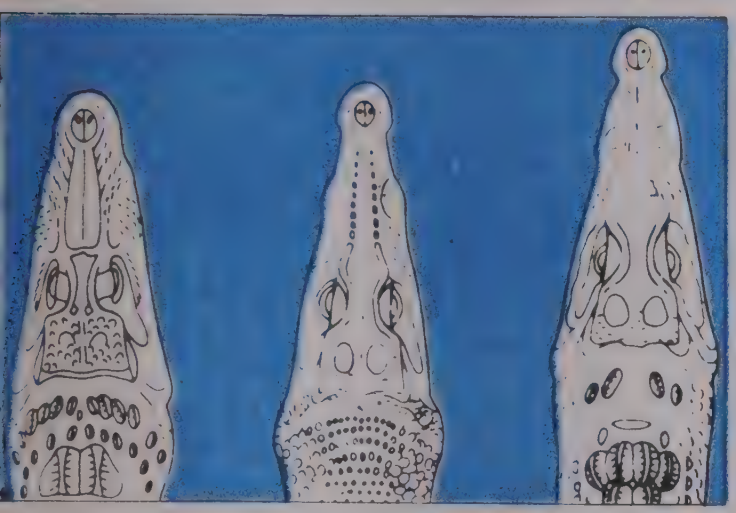


Above: Head of alligator (left) and of crocodile (right). The alligator has a broader and rounded snout with the nostrils placed slightly apart

The Nile crocodile



(Right) The false gharial (*Tomistoma schigelli*) found in Malaysia and Borneo



(Left) A: Spectacled caiman *(Caiman crocodilus)*
B: Saltwater crocodile *(Crocodylus porosus)*
C: Cuban crocodile *(Crocodylus rhombifer)*

of about 7 m and 5·5 m, and t females with lengths of about 4·6 and 3·4 m, respectively.

In *free-range mana ment*, the crocodiles of an area, whi could be a lake or a reservoir, or section of a river or a tidal cre are managed *in situ*. All the stock, the young ones being grown to b come future breeding stock, are free ranged. Stocking rates are adjusted a range of environmental paramet including food supply. In this meth the housing costs are eliminated. T aims are two-fold: (*i*) to ensure t conservation of the crocodilian speci and (*ii*) to build up an export indu try with maximum foreign exchan earnings from crocodile leather.

Economists estimate that once th Satkosia gorge is restocked, th annual profit from skins alone will b as high as Rs. 1,500,000. Crocodi meat which is a delicacy in countri like Japan, may also fetch about Rs. 4 per kg.

This is not an optimist's dream Captive breeding has been tried ou

Thus, unless the conditions are suitable and food is available in sufficient quantity, the young may perish. Once feeding has commenced, tadpoles, too, are offered on alternate days.

As the young increase in size, the size of the fish offered is also increased. After 3–4 months, the baby gharials are given, in addition, one small white rat each, once a week. Growth at this stage is rapid, at the rate of about 7·5 cm per month.

Each pool accommodates 10 to 12 crocodiles. They always remain in groups. Gharials never fight with each other for food, whereas muggers are notorious for this.

The secondary pools for the one-year-old gharials have dimensions of 4·6 × 4·6 × 1 m. Each pool is surrounded by about 1 m width of sand, 15 cm deep. Gharial hatchlings grown to a size of about one metre are reared in these pools for about another year before they are let into the Satkosia gorge of the Mahanadi — once considered the last stronghold of the gharial. But relentless slaughter has made them almost extinct even here. One great reason for the depletion of the gharial population here was the introduction of commercial fishing. Fishermen would kill them not only for skins, but also whenever they got entangled in their fishing nets, in order to save the nets. (The Government of Orissa has issued nylon nets to the fishermen which are put across daily within the gorge.) Today, the Satkosia gorge has only four adult gharials left; two males with lengths elsewhere and one of the rarest species the African dwarf crocodile, was bred in captivity for the first time this year in Zoo Negara in Malaysia. Perhaps the most successful — a commercial venture for skins — is the famous battery crocodile farm at Samut Prakan in Thailand, said to be the

BREEDING CENTRES IN INDIA

Gavialis gangeticus (gharial): Satkosia gorge, Tikerpara, Orissa, and Lucknow UP.

Crocodylus porosus (saltwater or estuarine crocodile): Bhitarkanika in Orissa and Kakinada estuary, Andhra Pradesh.

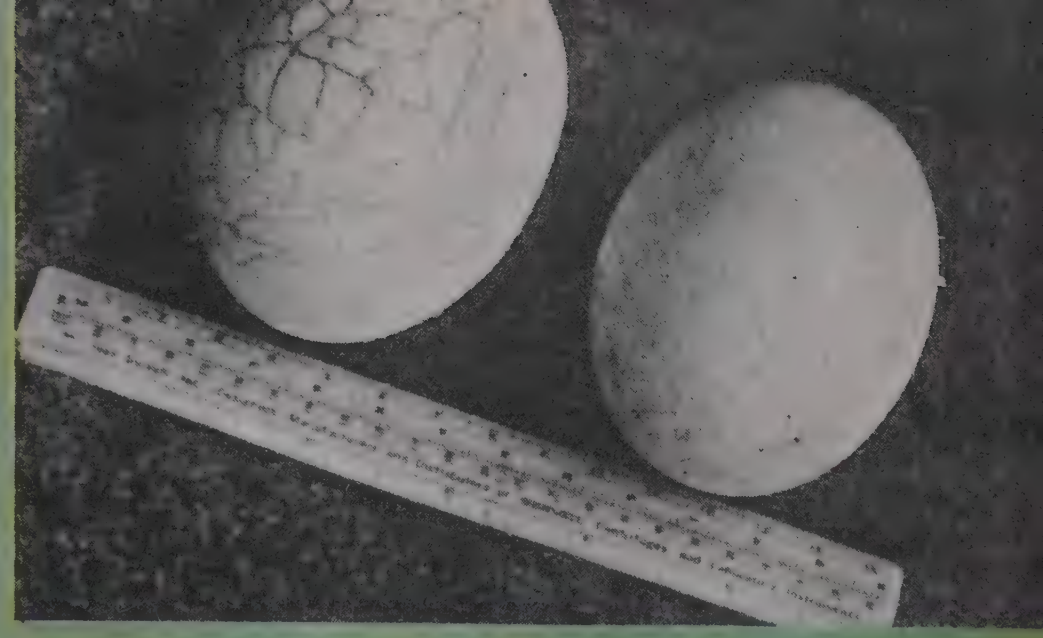
Crocodylus palustris (mugger or marsh crocodile): Madras Snake Park, Guindy Tamil Nadu, Nagarjunasagar area in Andhra Pradesh and in Gujarat.

world's largest. Started in 1950 by Uthai Youngprapakorn with just 20 wild crocodiles and a capital of $500, last year the farm had 18,000 crocodiles that put the farm's worth at about $2 million.

In India, the preservation of the seriously threatened crocodile population received attention for the first time in May 1974, after the visit to India of FAO expert Dr. Harold Bustard. And since the sanctioning of the first crocodile farm in Orissa, there has been much activity all over the country. Attempts to breed have been successful at many centres. By January 1977, 120 gharials were hatched in Orissa alone. The five-year project for breeding and management of crocodiles, started with UNDP assistance, is managed by the FAO (in collaboration with the Ministry of Agriculture) and has its headquarters at Hyderabad with training centres at Lucknow and Hyderabad. When the project started in late 1975, there were only 60 to 70 gharials in India; within a year 450 baby gharials were reared. At present, some 1,400 gharials are growing in various sanctuaries — Satkosia gorge in Orissa, Chambal river in Rajasthan, Katernaia Ghat in Bahraich District in UP. More interestingly, seven PhD scholars are working with Dr. Bustard along with 1,500 tribal workers.

One last point. While preservationists are chiefly concerned about giving the dwindling species a chance to live and proliferate, any small success in the breeding operations anywhere in the country immediately sparks off ambitious estimations in the government departments as well as in the press about the "returns" that will start flowing in after crocodile populations have reached a viable number when they can be killed for exporting skin and meat. This is not a healthy attitude. The primary aim at the moment should be to preserve the species alone and not in counting financial gains earned from killing before the crocodiles are even hatched.

HATCHING OF A CROCODILE



(Top) Crocodile eggs. The one on the right is of an early stage (6·75 cm×5·5 cm). The egg on the left has increased in size (7·5 cm×6 cm) and the cracks that have developed indicate the egg is due to hatch soon

(Centre) Hatching of the mugger at the crocodile hatchery of the Nehru Zoological Park at Hyderabad. Weight: 85 grams; size: 25 cm long. (At the Hyderabad hatchery, out of 145 eggs collected, 103 had hatched, which means natality of 71 per cent)

(Bottom) A baby mugger, five-day-old

Dr. Subba Rao teaches ecology and physiology at the Post-graduate Department of Zoology, Utkal University, Bhubaneswar. He is a member of the Integrated Crocodile and Sea Turtle Project of the Government of Orissa.

Fig. 6 Three-day-old mugger hatched last June at the mugger hatchery of the Nehru Zoological Park, Hyderabad

A non-scaling column for alcohol distilleries

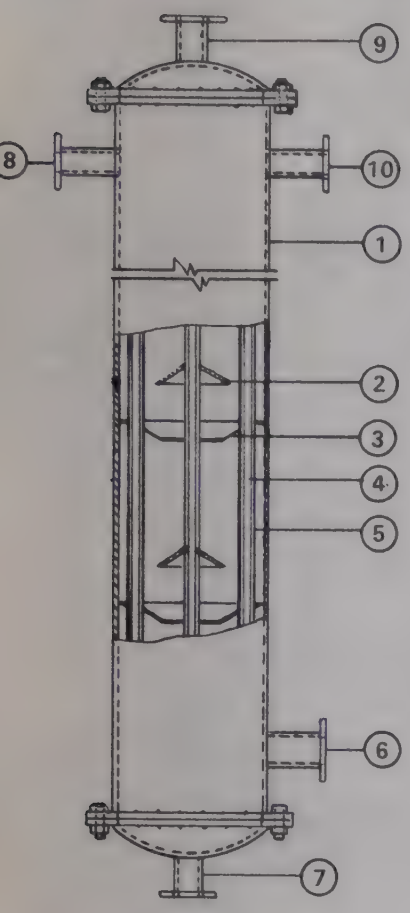


Fig. 1 Non-scaling distillation column. 1. Shell 2. Disc 3. Doughnut 4. Tie rod 5. Spacer 6. Vapour inlet 7. Reboiler 8. Feed inlet 9. Vapour outlet 10. Reflux inlet

Scaling is one of the major problems encountered in the chemical process industry in general, and in alcohol distilleries in particular. Due to water hardness, scales form on the tubes of the evaporator; this lowers its heat and mass transfer capacities. In the alcohol distillery, scaling occurs on the plates of the analyser column with the formation of a hard crystalline mass (scale) consisting mainly of calcium sulphate and other salts. The scales are extremely hard, varying in thickness from 1·5 cm to 5 cm. There is a gradual reduction of the capacity of the column, since the scales choke the holes of the vapour ports of the column, resulting in a low turn-down ratio and, finally, shut-down of the plant for cleaning the trays. Scaling reduces the overall profitability of the unit.

A non-scaling distillation column designed and fabricated in the Regional Research Laboratory, Bhubaneswar, is shown in Fig. 1. The column can replace the existing analyser column in alcohol distilleries. In the column, plates of slanted discs and doughnuts are mounted on tie-rods alternately in the form of a cartridge, facilitating easy insertion into the column (Fig. 2). The doughnuts are provided with suitable gaskets on the periphery to form a tight seal against the column shell, preventing leakage of the vapour. The main design criterion for the tray is that the high vapour velocities are created so as to impart vibrations to the thin plates of the discs and doughnuts. These vibrations make the scale deposits slide down the slanted surface of the plates, and these finally exit through the central hole of the doughnut. The formation of scales of the plates is thus prevented.

The column was tested with a synthetic solution of dilute alcohol as the feed. Calcium sulphate was mixed into the feed as the scaling agent. The feed was heated to about 70°C and then introduced into the feed tray of the column. Live steam was injected from the bottom of the column. Stripping of alcohol from the dilute aqueous feed, along with the calcium sulphate, was studied. After prolonged operation of the column, the plates of the column were removed for inspection and analysis. There was hardly any deposition of the scale on the plates.

Although the relative efficiency of the type of tray used in the column is low, the cost of the tray is muc less than that of other trays. Th design of the column is covered by a Indian patent.

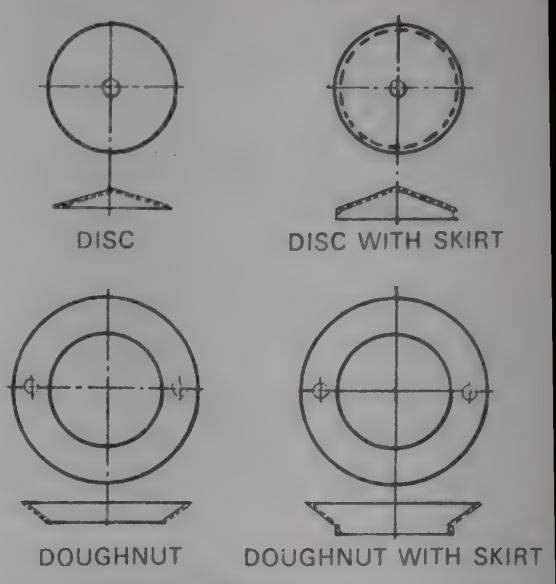


Fig. 2 Details of baffles

A. RAMAKRISHNA RA
K. MADHUSUDAN RA

[The authors are with the Regional Researc Laboratory, Bhubaneswar.]

Wheelchair for the disabled

While there are many problems of the able-bodied demanding immediate attention, the handicapped minority, whose number is steadily increasing, has remained relatively neglected. To the disabled, what hurts most is their dependency on others for simple daily activities, and the attitude of sympathy and pity.

A physical aid, therefore, plays a crucial role in the lives of the disabled. And for those whose lower limbs are incapacitated, the wheel chair is a convenient device to sit o and move about. The existing whee chairs in our country are, howeve heavy, expensive and unwieldy. The usually have a hard seat which trans fers the jerks and shocks from th undulated ground to the thighs. Th four small castor wheels make it ver difficult to go over ditches and othe obstacles; turning is also a little diff cult. Some chairs are foldable, but a there is no locking arrangement, th chair tends to fold with every jol

The wheelchair fo the disabled de signed at the Na tional Institute o Design, Ahmedabad

ll main structural members are ivoted to a single point to facilitate olding of the unit. So, the whole veight of the occupant acts on this ngle pivot point, making the chair tructurally weak. The back rest and ne foot rests are fixed, and not djustable for people of various heights nd physical builds.

Besides, most of the wheelchairs do ot have hand-rails for wheeling, hich means dependency on someone lse for moving it or handling the olling wheels which carry dust from ne ground. The foldable wheelchairs ave a canvas seat, but as the frame not rigid, in actual use the seat ecomes uncomfortable.

Unlike ordinary chairs which are sed at a fixed place for a definite nction, a wheelchair has to carry s occupant from place to place to erform different tasks. Almost all xisting wheelchairs seem to overlook his important aspect. They do not, or instance, take into consideration ne height levels of the sanitary fittings n Indian homes. Even our best heelchairs are still those which were iven as aid or imported. They do not uit well the social, psychological and hysical requirements of the Indian ser.

These were the considerations be-

An important feature is that the chair has detachable foot rests which could be adjusted to suit the user's resting requirements. The wheelchair also folds into a more compact size than the existing chairs for convenient storage and transport in buses, trains, etc. The unfolding is lockable. The wheeling hand-rails are made of cane, which is lighter and cheaper.

The design was developed after a close study and continued dialogue with disabled persons at the Apanga Manav Mandal at Ahmedabad. Reactions from inmates who tried the prototype were quite positive.

This chair could be produced by a smallscale unit. Standard components like pipe joints, tubes and standard bicycle wheels are used to reduce the cost. When mass produced, the cost is estimated to be 30 per cent lower than that of the existing wheelchairs. The wheelchair is not presently being produced by the NID or anyone else. A second prototype from the production feasibility point of view is being designed at the NID workshop.

S. BALARAM

ind the design of a new wheelchair t the National Institute of Design NID), Ahmedabad. The chair is onstructed in lightweight mild steel ube to be strong as well as stable and ss prone to vibrations. It has three heels, instead of four. The two main heels are standard bicycle wheels, hereas the third, supporting wheel the rear is a standard castor wheel. large-size castor wheel of 20 cm iameter is chosen to facilitate easy novement on uneven ground. The ngle castor wheel provides a better urning facility within a 40 cm radius. his rear wheel is attached to the ody with a cantilever which gives a uspension effect and absorbs normal hocks and jolts. The rolling noise of he wheels has also been considerably educed.

The seat and back rest are designed s a single detachable unit; this helps he transfer of the person, particularly he/she is a child. This unit can also e used as a seat for writing, reading, tc (see figure in next column).

The single unit has a rigid frame tted with a comfortable leather seat hich could be tightened whenever ecessary. The seat itself could be ttached to the body at different evels to suit different users, a child r an aged one. The minimum level kept at 36 cm to match the height f the Indian toilet seat, so that the ransfer is easier.

Immobilised enzymes

Enzymes are well-known as catalysts. They facilitate reactions of highly complicated chemistry. But a problem in enzyme-catalysed reactions is the recovery of the enzyme. Since enzymes are used in very low concentrations, their recovery is not possible.

A technique to keep the enzyme in the reaction system and still make it easily recoverable is to immobilise the enzyme — by physically or chemically bonding it to a polymer substrate which does not react with the reactants. The enzyme can be separated by filtration after the reaction is complete. Substrates such as polymer fibres, hollow spheres or solid particles have already been reported. A relatively new substrate is a cellulose derivative, modified to reduce the hydrophilic nature of cellulose. Adsorption of the enzyme on the modified cellulose takes place specifically on the newly formed hydrophobic surface (*Chemical & Engineering News*, **55,** 22–23, 1977).

The polymer, phenoxy acetyl cellulose, is prepared by reacting phenoxy acetyl chloride with cellulose suspended in a 1 : 1 mixture of pyridine and dimethyl formamide at 70°C. After standing overnight, the supernatant liquid is decanted and the product is purified by several washings with ethyl alcohol. The compound can be stored dry. In aqueous media, however, it slowly hydrolyses. To bind the enzyme, a solution of the enzyme is passed through a column packed with the modified cellulose. The cellulose binds about 0·3 to 0·5 per cent of its own weight of enzyme, which retains a high activity. The activity of enzymes bound in this way will be higher than those bound by conventional techniques of inclusion of enzyme in a polymer or a gel where only a small portion of the enzyme is exposed to the reaction.

Though the practical applications of the technique are still to be established, the possibilities are quite wide. Cellulose is available in several forms — fibre, thread, sheet, cloth or powder. All of these may be used, depending on the amount of the enzyme needed and its contact time with the reactants; for example, enzyme-treated filter paper can simplify the clarification of juices. Enzymes immobilised on phenoxy-acetylated strings can simplify analytical and clinical procedures now performed with soluble enzymes. If the enzyme activity is standardised per unit linear measure of the string, unskilled workers can measure out and use precise amounts of the enzyme just by taking out the right length of the string. The enzyme can be added to, or removed from, a mixture without otherwise affecting its composition, merely by inserting or pulling out the string.

Besides, the new technique can help make several interesting products. If a cloth is made from derivatised fabric bonded with an enzyme, a self-cleaning cloth will result. Cellulose enzymes bound to derivatised cellulose could lead to self-dissolving packaging materials. And wound dressing made with gauze treated with proteolytic enzymes can promote quicker healing.

V. C. MALSHE

Padekar

DIAMONDS

M. L. DESHPANDE

It's an old Persian legend that says, when God made the world, he made no "useless" things like gems. It was the work of Satan, who took the colour, lustre and beauty of flowers from the Garden of Eden (which Eve so loved) and hid them in the earth as gem stones — emeralds, sapphires, rubies, diamonds, — so that the evil of avarice would be perpetuated through time. The lure of gems, particularly diamonds, may not be entirely satanic, but there is indeed something of the magical about it, since, in every phase of recorded history, people have associated them with both good luck and ill fortune, paid fabulous sums, fought wars, killed or adopted other devious means to possess them.

Few of us are aware that a diamond retrieved in the 'rough' is still a long way off from the cut and polished gems that are put up for sale with price-tags of four, five or still larger digits. The reason, for one, is that to produce seven tonnes of diamonds, over 150 million tonnes of diamondiferous ore must be hauled to the surface and processed. For another, the "cutting" is so tricky that a single careless cleavage can shatter a large piece into worthless splinters. And, then, there is the question of colour (or its absence), inclusions and flaws that determine the price of a gem diamond.

Before we proceed further, it must be made clear that diamonds are not all that "useless" as the legend quoted earlier says. Today, they are an invaluable aid in industry (for use in cutting tools and a host of other industrial applications) and, besides, the non-gem diamond pieces are themselves used in cutting and polishing the gem ones. Behind all this, there's a simple reason: diamonds are the hardest material known to man.

What is a diamond

Believe it or not, a diamond is nothing but a crystalline form of pure carbon. And strangely, its closest relative is graphite, the 'black-lead' of our pencils, which is the other crystalline form in which carbon occurs in nature. It must have been one of nature's whims that fashioned these two — the soft, greasy graphite, so soft that it can be used as a lubricant, and the hard diam which is indeed so hard that it ca cut with only another diamond.

This hardness of the diamon due to its atomic structure. carbon atom in diamond is bonde four neighbouring carbon atom closely and symmetrically that almost impossible to press the at any closer than they are. No wo diamond has a density 3·5 times of water.

We still do not know for sure diamonds came to be formed in earth. But the assumption is diamonds crystallised from carbo a depth of about 160 km, where t the pressure and temperature ne sary to transform graphite car into diamond exist.

If a diamond is heated to, 1200°C, it slowly converts to graph The transformation becomes ca trophic if the temperature is raise about 1900°C. For instance, betw the carbon poles of an electric diamond is converted to graph The graphitisation can, however, arrested by increasing the press around the diamond. Conversely graphite is heated to, say, 250 and then a huge pressure is appl (at least 100,000 atmospheres), it be transformed into diamond. vided the temperature cools do before the pressure is released, diamond, once made, stays put. bably, this is how diamonds grew the earth.

How did the diamonds, formed such great depths, reach the surf where they are usually found? H too, the presumption is that t were forced up from below dur geological upheavals, encased in v deep, cylindrical-shaped pipes called kimberlites, meaning "b ground" (from its colour). The mo ment seems to have been mainly matter of pressure, as there is evidence that the pipes had b exceedingly hot on their way up. typically 'large' pipe is usually oval shape and can be as much a kilometre across.

Diamonds also occur in alluv deposits, river-beds or even mar beds. The so-called marine diamo are merely extensions of coastal a vial deposits, running directly shore. Alluvial deposits may be the surface, or in gravels or under "overburden" of sand up to metres thick, or indeed on rou pebbly sea-beds. There is very go reason to believe that such diamo originally came from pipes wh were forced above ground level a were later weathered down i gravel-like deposits. Ultimately deposits must have been washed i

ver-beds, towards coastal regions nd into the sea.

Virtually all known iamonds before the 18th century ame from India, from surface alluvial eposits around the small town of olconda near Hyderabad in Andhra radesh. Most were small diamonds, ough several quite famous large iamonds were also recovered. Some f them like the Koh-i-Noor, Hope, rloff, Akbar Shah, Darya-i-Noor, reat Mogul, Nepal, Regent, etc ave become historical legends. The olconda mines virtually dried up in ie mid-18th century.

Just as the Indian sources were rying up, a new source was dis-overed in Brazil in the state of Minas erais in 1725 (a priest who had ecome familiar with rough diamonds India recognised these stones in the ashings for gold in Brazil) and in ahia in 1842. The latter contains an nportant variety of diamond called rbonado. It is black and opaque just translucent with a metallic ine and, hence, called black dia-ond. Carbonado is extremely strong nd is of great value for industrial es, especially as a drilling tool and r shaping hard materials. The dia-ond deposits in Brazil occur both in w-lying river valleys and on high ateaus, but so far it appears that ie original pipes have not been und.

The outlook of diamonds both as a em and as an industrial material ok a remarkable turn with the dis-very of diamonds at Hopetown on ie banks of the Orange River in outh Africa in 1866. The first large-ale mine to be opened up was at ie Bultfontein in 1869. In 1871, new nds at Dutoitspan led to a wild rush prospectors and by the next year, ve important diamond bearing pipes ere uncovered in the Kimberley rea. What distinguished South Africa

The " Hope " diamond, 44·4 carats, deep sapphire-blue in colour, is haunted by legends of bringing ill luck to its owner — eleven violent deaths, tragedy in two royal houses. Now in private ownership in the US, the diamond which took its name from one of its earlier London owners, is believed to be part of the Tavernier Blue.

Jean Baptiste Tavernier, a French geographer who came to India in 1638 to buy precious stones, took back with him a huge blue diamond which he sold, along with 24 others, to Louis XIV in 1668. The Tavernier Blue was recut and made part of the French crown jewels. They were stolen in 1792 but the Tavernier was not among the few gems subsequently restored. Later it reappeared, much reduced in size, as the Hope diamond.

from other areas is that seemingly inexhaustible supplies of diamonds were found locally in deep volcanic pipes.

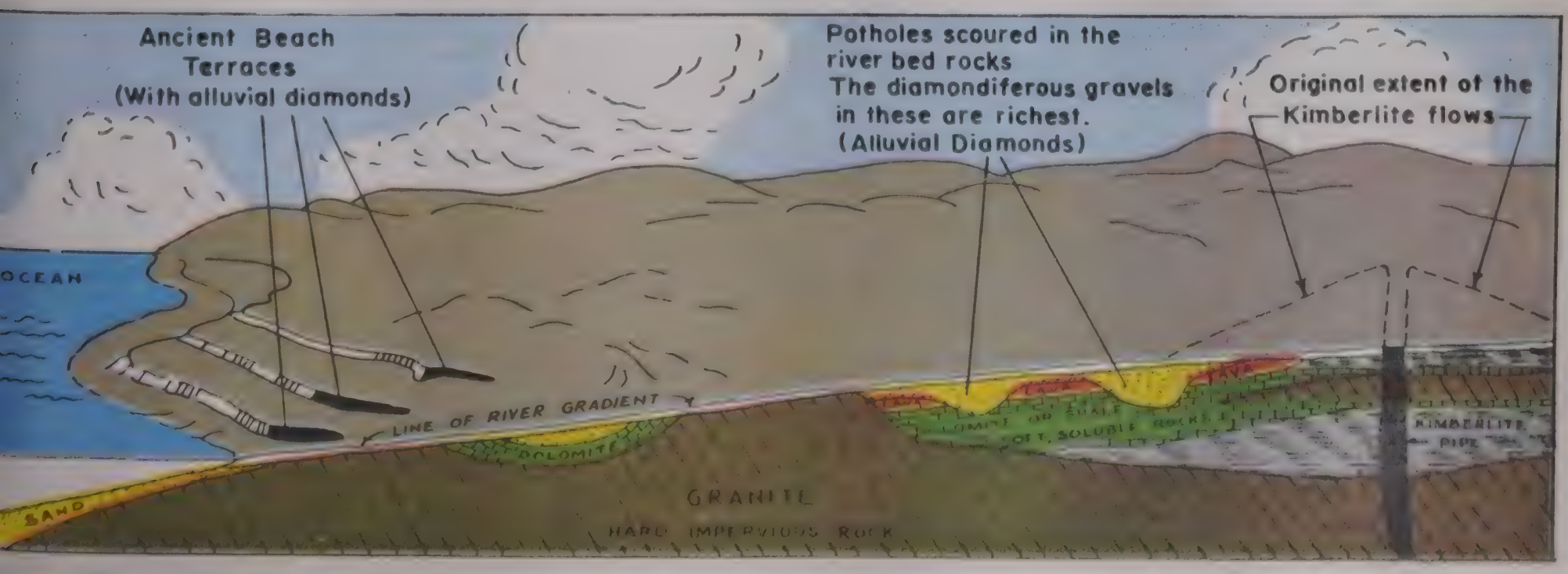
A more interesting discovery in the African continent was the location of rich deposits on the coast of Nawaqualand in South-West Africa and a little later on the coastline north of the Orange River in 1925. This region is the world's richest source for high-quality gemstones. Almost the whole output is of gem quality, unlike in even the best South African mines. In contrast, a diamondiferous area of about 100 million hectares stretching into neighbouring Angola which was discovered in the Belgian Congo in 1910, yields diamonds almost entirely of industrial quality (only two per cent suitable as gemstones). Other African sources include Ghana, Sierra Leone and Tanganyika. Diamond mines mostly in inhospitable and inaccessible areas are reported to have been discovered in the Soviet Union, but very little is known about the total production of these mines. However, Russia is now the only great industrial power completely independent of the African sources for the supply of industrial diamonds.

To be rated as a ' perfect ' gem, a diamond must be flawless. Impurities like ferric oxide, silica with traces of lime and magnesia together with gaseous inclusions like carbonic acid constitute the ' flaws ' (it is today standard practice to use the term ' inclusions ' in place of ' impurities '). The solid inclusions normally include garnet, diopside, olivine, pyrrhotite, chlorite, zircon, mica, etc. The presence of gaseous and other inclusions can reduce the density up to 3·10 gm per cc. The iron oxide is normally responsible for giving diamond the yellowish tinge.

Acids or alkalies do not act upon diamonds, nor does heat (except at temperatures above 800°C in oxygen or even in air, when it oxidises to carbon monoxide, or carbon dioxide). But if heated anaerobically to about 1900°C, it turns into graphite. Diamond can readily be oxidised and destroyed in a flux of sodium carbonate or of potassium nitrate.

However, it is in the uniqueness of its varied physical properties that diamond takes its place as the king of gems. Take, for instance, its form of crystallisation. The diamond crystallises as regular cube (only small diamonds from Brazil), octahedron, hexahedron

g. 1 Diagram of weathering erosion and transport of diamonds to gravels from host rock ' kimberlite '



tetrakishexahedron, rhombohedron and rhombdodecahedron — the forms belonging to the cubic system of crystallisation. Some morphological studies on Indian and South African diamonds indicate that many of the crystals belong to the tetragonal system of crystallisation. The structure of diamond consists of two similar Bravais lattices of carbon atoms of the face-centred cubic type, interpenetrating each other. Each atom in one of the lattices is linked to four atom the other lattice by valence bo along the four trigonal axes of s metry. Twinned crystals are uncommon along the octahe plane.

But the much talked-about ha ness of diamond differs along across) different axes of the crysta

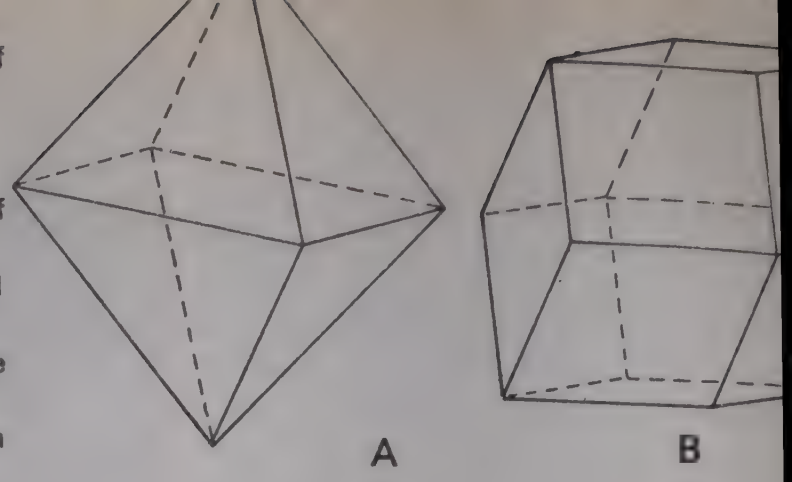


Fig. 2 The crystal planes of diamond

A: Octahedron

B: Dodecahedron (both common forms of diamond)

C: The hard (111) octahedral face

D: The soft (100) cubic face (making the 'table' cut)

E: Direction of cleavage on an octahedron

Processing of diamond ore

The extraction and recovery processes for the 'run of mine' ore differ from deposit to deposit and there is no fixed scientific method. In the 'treatment plant' the following processes are used so that a fixed quantity of the ore is treated daily for continuous recovery of diamonds: (1) primary crushing; (2) secondary crushing; (3) grinding; (4) screening for separation of different size fractions; (5) concentration; and (6) picking (manual-mechanical).

In case of 'run of mine' ore from kimberlites and older conglomerates, all the above processes have to be taken stage by stage, while in the case of unconsolidated gravels, stages (1), (2) and (3) can be skipped. In the case of kimberlites, the blue and yellow grounds (upper weathered parts of the volcanic pipes) are much softer than the hard kimberlite, and it becomes necessary to soak the 'run of mine' ore in water to remove the clayey slime; this may constitute up to 50 per cent of the total 'run of mine' ore. Also, in the case of certain soft layers at the bottom of diamondiferous conglomerates, such as the Banganapalle conglomerate in Andhra Pradesh, water-soaking in the initial stage may be necessary. The hard material is sent directly to crushers.

The 'run of mine' ore is brought to the treatment plant by dumpers and unloaded into the ore bin. The bigger pieces are crushed to enable them to pass through 250 mm size sieve and then fed to jaw crushers. The smaller-sized crushed material is sent to vibratory screens whereas the oversize material is passed through a roll crusher for secondary breaking. This, along with the undersized material from the vibratory screen, is taken by conveyor belts to finer size ore bins. The oversized material at this stage is sent to the secondary grinding mill or ball miller, where it is further reduced in size by steel balls. The crushing is done in stages to minimise the chances of breakage.

At the screening stage, the bigger size material is rejected first. The screening sizes may differ from plant to plant, and unless some diamond powder has to be recovered, sizes of the order of 1·25 to 1·75 mm are rejected. The screening provides materials of uniform size for feeding to the jigs (centrifuges).

The design of the jigs for concentration of the diamond-containing material also differs from deposit to deposit. Concentration is done by using the density difference between diamond (3·1 to 3·5 gm per cc) and gangue (valueless) material (around 2·8 gm per cc). The jigging is done using water as a medium, and concentrates of different sizes are obtained at every jig. This process considerably reduces the amount of material that must go to the 'pickers'.

The pickers are experts who work by spreading the concentrates on cemented floors. Alternatively, the concentrates are carried over grease tables: diamonds stick to the grease and are removed. The efficiency of the grease table method arises from a curious property of diamond surfaces, namely, neither diamond nor grease is wetted by water so that the diamonds adhere to the grease. All other minerals are effectively coated (in the water) by a water layer and so slide off the sloping grease table. In modern plants, the diamonds are picked up from conveyor belts by using the technique of X-ray fluoroscopy which detects *all* diamonds present in the charge. There is no risk of any diamond being lost in this operation.

For the river and marine beach deposits containing diamonds, the constitution of the gravels, namely, the boulders, cobbles, pebbles, granules and the binding clay in which the diamonds are caught up, must be known for designing the treatment plant. Here the processes involved are washing, screening, jigging and diamond picking — all very similar to the treatment of primary kimberlitic ore or the secondary conglomerate ore. The 'run of mine' gravel is first dumped at the jarway over the 12·75 cm grizzley and later fed to the hopper bin. The conveyor belt then feeds the material to the mixer trommel. The very coarse materials (size greater than 2·5 cm) are sent to waste. Products smaller than this size are kept in the hopper and fed to vibrators where they are screened for different sizes. These are then sent separately to jigs for concentration. The concentrates thus obtained are sent to the yards for picking diamonds. (The above operations are carried out in a continuous circuit.)

The diamond roughs obtained from the treatment plants are examined and weighed; they are then classified into gems and industrials. The weight of diamond is expressed in carats, where 1 metric carat is equivalent to 200 mg. The diamonds are normally auctioned as roughs. The gem quality goes to the gem cutting industry, while the industrials are sold as per specifications to different factories.

M. L. D.

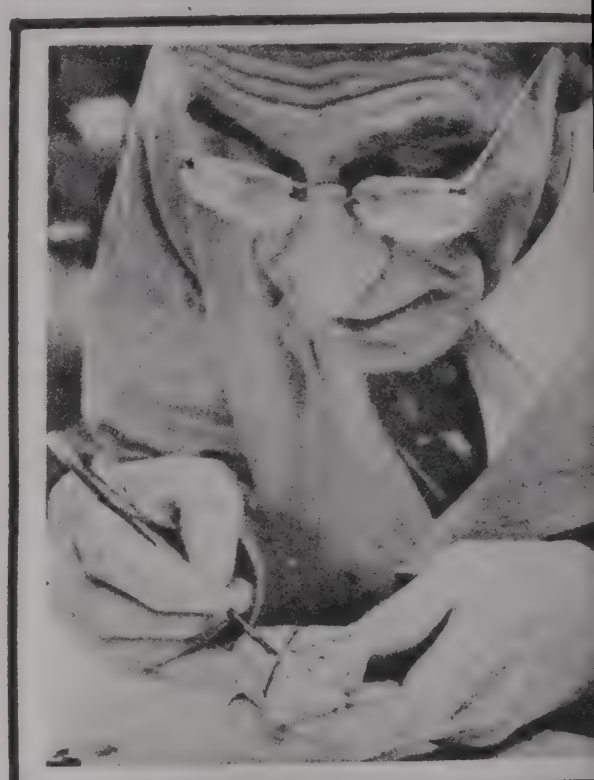
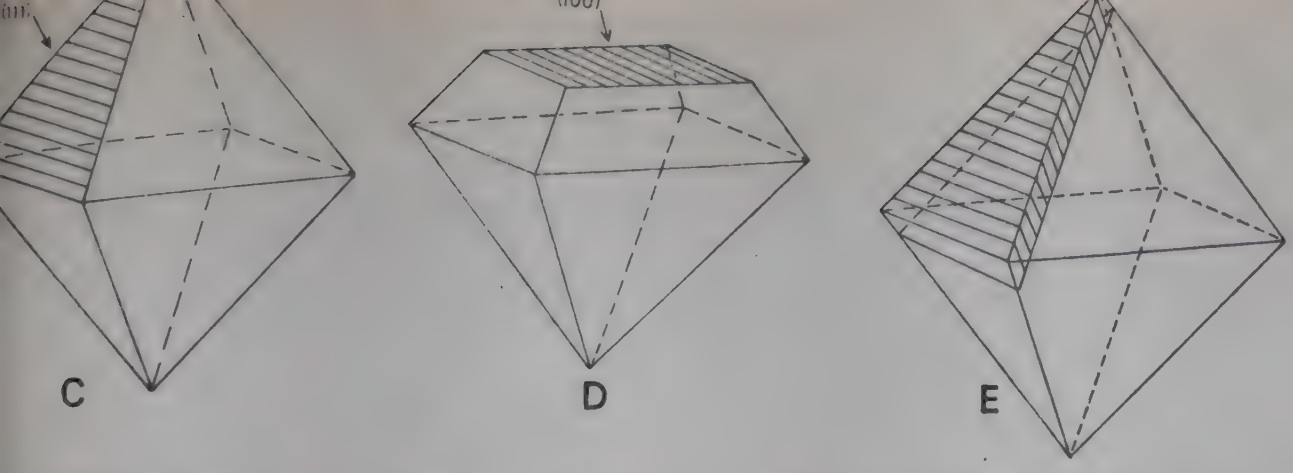


Fig. 3 A cutter traces lines of cleavage on surface of a rough diamond with pen and After weeks of study, the stone is groove receive a mallet tap at the likeliest spo slight mistake may splinter the stone into pi

How are the axes of a cry defined? A crystal has a uniform sy metrical arrangement of atoms, t is, a unit atomic grouping wh repeats itself regularly an extrem large number of times. It is the u atomic grouping which determi the final shape of the crystal. T forces binding the atoms together c however, act with different streng in different directions. Consequen in every natural crystal, the physi properties vary in different directio The directions in a crystal are defi with respect to the crystal planes. T diamond crystal has eight "octah ral faces", each similar and triangu in shape. A number code system used in crystallography to define fa and each face is given the code (11 The octahedron can be truncated produce a square tabular plane. Su a plane is called a "cubic face" a

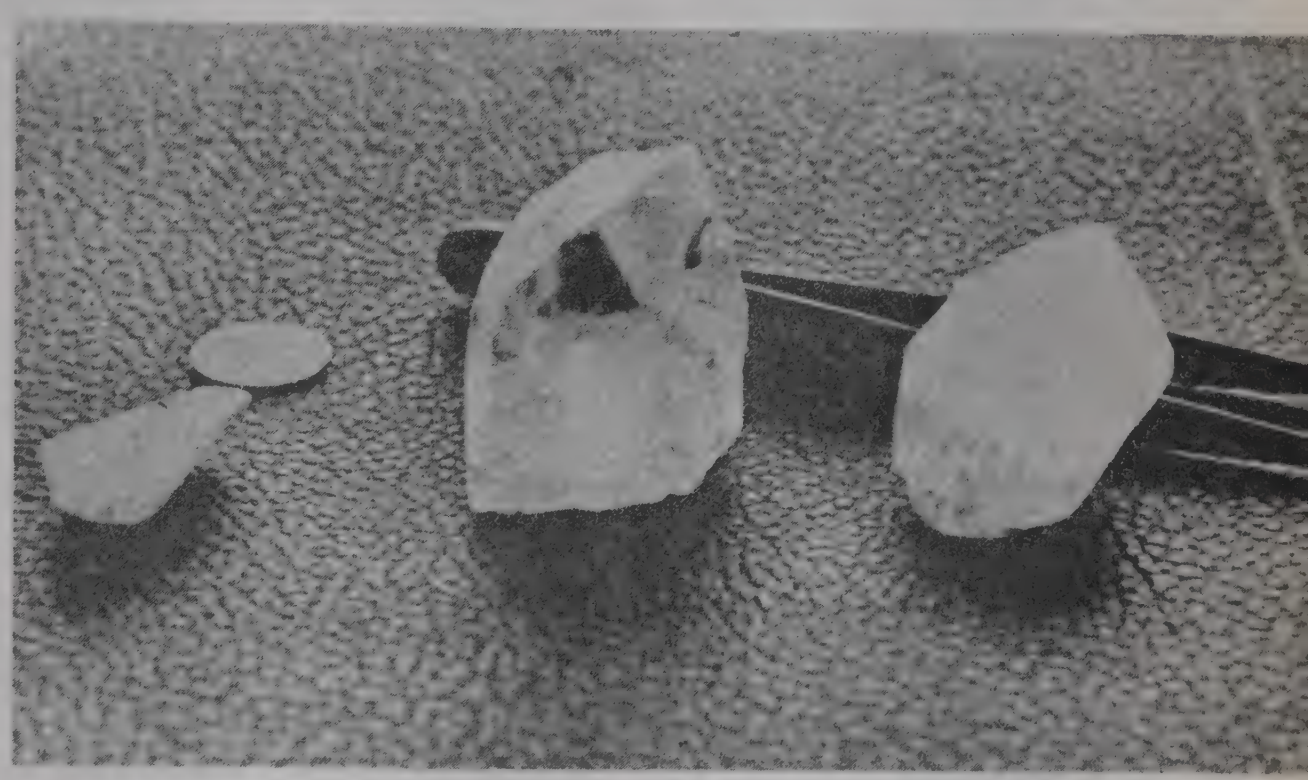


ts code is (100) (see Fig. 2).

The octahedral (111) face is the ' hardest ' " of all planes on a diamond, whereas the cubic (100) face is the ' softest ". This differential hardness, accidentally discovered though, was the first secret of the diamond polisher's art and was known to the guilds of lapidaries in the medieval times, who held it as a trade secret within the family. One of the practical applications of this knowledge was that table-cuts were produced by lapidaries by grinding down the diamond octahedra. The principle used was *diamond-cut-diamond*, that is, the harder direction of diamond could abrade the softer. The table cut can be found in numerous pieces of medieval jewellery, for example, in rings and brooches. Later, the lapidaries began to attack the edges of the table cut, to produce shapes called the " brilliant cut " (see Fig. 5). This cut retained as much of the original octahedron as possible in the final gem.

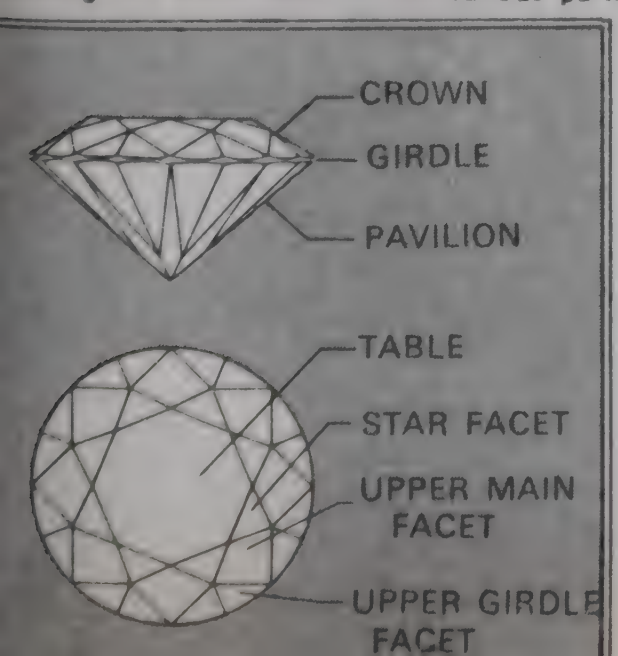
Another curious property is that despite its great hardness, a diamond crystal cleaves with little difficulty. Diamond possesses both octahedral and cubic cleavages, the latter being relatively perfect and is taken advantage of in cutting the ' roughs ' into gems. Cleavage is actually a special property shown to varying degrees by different crystals. This is because, the atomic arrangement in crystals is such that in certain directions the binding forces are uniformly a good deal less than in other directions. These looser-bound planes are the cleavage planes. In diamonds, the binding forces perpendicular to the octahedral faces are the weakest. It is possible to scratch a nick called " kerf " in the edge of a diamond with another diamond. If a knife-blade is applied to the kerf in the direction of the arrow in Fig. 2 E in such a way that the blade is parallel to the (111) face, a smart blow on the blade propagates a shock through the crystal, which splits perfectly down a plane parallel to the (111) plane and the shaded piece separates off. Skill is paramount in directing the blow correctly or else the diamond may scatter. However, while cleavage is most useful to a diamond polisher, since he can bring an irregular shape to a shape nearer to what he ultimately needs, it is sometimes a disadvantage in the industrial applications; a specially-shaped diamond lathe-cutting tool or diamonds embedded in the heads of rock-drilling tools can split apart by cleavage.

A further mechanical property closely related to hardness is that diamond is least compressible and its compressibility is somewhere near a quarter that of steel. The table below gives the comparative compressibility figures for some gems and metals. If the volume elasticity or otherwise the resistance to compression of steel is $\frac{1}{68}$, that of quartz will be $\frac{1}{267}$ and that of diamond $\frac{1}{18}$. It is, perhaps, because of this high volume elasticity that the diamond ore can be crushed without in any way breaking the contained diamonds. This property also plays a big part in the most common industrial use of diamonds — for drilling and for cutting hard alloys and hard materials. Also for a hard material, the friction of diamond is surprisingly low — when rubbed



ig. 4 Cutting the Jonker diamond. (Left) Lazare Kaplan's son Leo holds the dull-edged blade in the V-shaped groove made in the diamond and Kaplan prepares to deliver the fateful blow. (Right) The three pieces after cleaving was completed. After this, further divisions were made, but by sawing and not cleaving. Cleaving is done in the direction of the grain, but sawing is done against the grain and is immensely slow

ig. 5 Two views of a ' brilliant ' cut diamond showing the terms used for the various parts



Substance	Compressibility (expressed as $\delta v \times 10^8$)
Diamond	18
Topaz	61
Emerald	75
Quartz	267
Glass	250
Copper	86
Steel	68

SOME FAMOUS DIAMONDS

JONKER

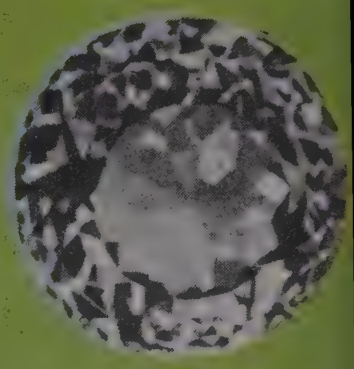
Found in 1934, it is considered to be the most beautiful diamond known. It has a blue-white colour. In its rough state, it weighed 726 carats

CULLINAN

The biggest diamond found in the rough state (3,106 carats) came from the Premier mine in Transvaal, South Africa, in 1905. Known as the Star of Africa, it was cut into a pendeloque brilliant (shown here) weighing 530·2 carats (Star of Africa No. 1) — the largest cut diamond in the world — and is now mounted on the British royal sceptre. The other, a square brilliant weighing 317·4 carats (Star of Africa No. 2), is set in the Imperial royal crown

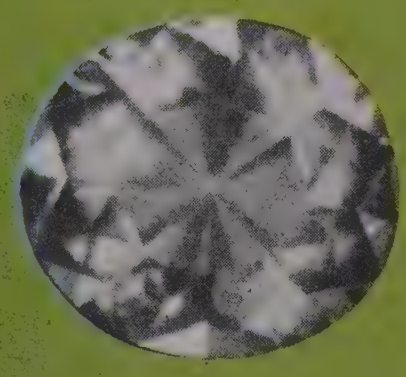
GREAT MOGUL

This famous 119·6 carat diamond, believed to have originated from India, has disappeared. (Some say it is in Iran, some believe it is in the Russian treasury in Moscow)



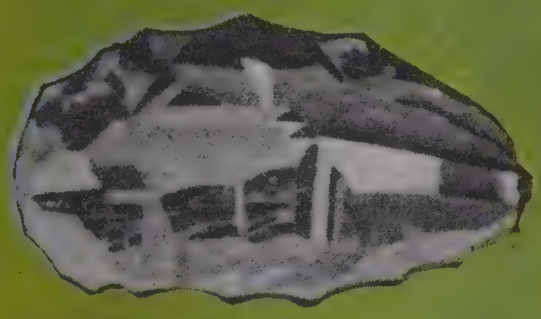
KOH-I-NUR

Legend says, this famous diamond was recovered from the gravels of either the Krishna or the Godavari river. Its known history dates back to 1304; however, the first authentic reference is in the memoirs of Babur (see facing page). Recut in 1862, it now adorns the front crossplate of the British royal crown



FLORENTINE

Well-known for its yellow colour, it is now in Hapsburg, Vienna



NIZAM

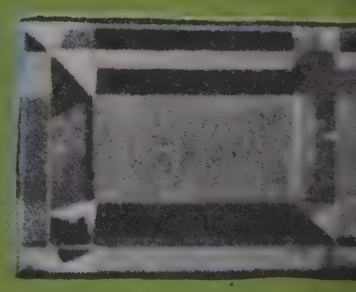
An enormous gem (277 carats), it is in the possession of the Nizam's family in Hyderabad, Andhra Pradesh

DRESDEN GREEN

Apple-green in colour, this 41 carat diamond is in the Green Vaults at Dresden, Germany

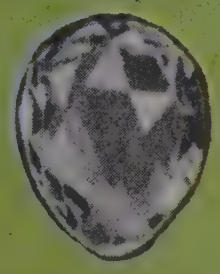
DARYA-I-NUR

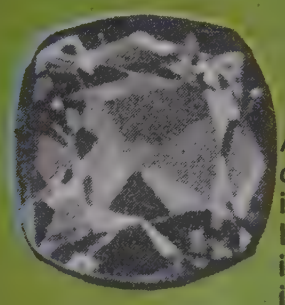
Once in the possession of the first Mughal emperor, it was plundered (probably by Nadir Shah) and taken to Iran. Now in the Teheran vaults. (Weight: 182 carats)



It has had an involved history. It has been owned by Charles the Bold, Elizabeth I of England (probably), Mazarin, Louis XIV and XV, and Marie Antoinette. Now in a private collection in England

SANCY



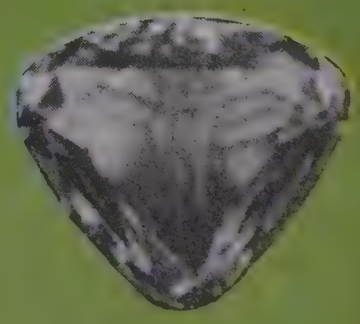


REGENT

Also known as "Pitt". 140·5 carats, perfect brilliant cut. Said to have been recovered from the gravel mines in the Krishna district in Andhra Pradesh, it was bought by William Pitt when he was Governor of Madras. Later it was acquired by France and Napoleon had it mounted in the hilt of his sword

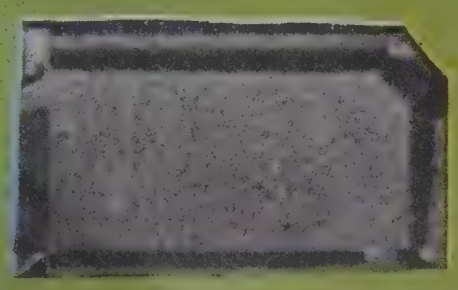
NASSAK

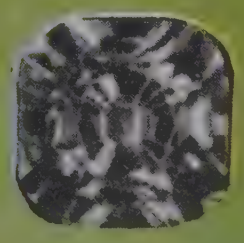
A 80·3 carat, brilliant cut, famous for its triangular shape



WHITE TAVERNIER

The stone weighed 242 carats. Last heard of when an inventory was made of the French Crown jewels in 1791. It has now disappeared. It was seen by Tavernier in Golconda in 1642

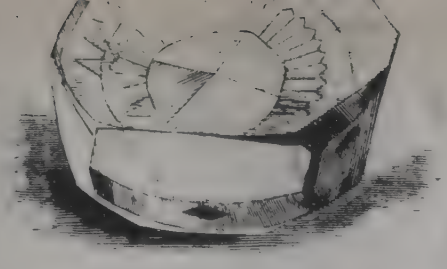




STAR OF ESTE

A comparatively small stone of about 25 carats, it is noted for its perfection of form and quality. Present ownership unknown

THE KOH-I-NOOR



Some say the Koh-i-noor is over 5,000 years old. However, the first authentic reference is found in the memoirs of Emperor Babur, founder of the Mughal dynasty in India. Babur wrote in 1526: "Bikermajit, a Hindu, who was Raja of Gwalior, had governed that country for upward of a hundred years (*sic*).

"In the battle in which Ibrahim was defeated, Bikermajit was sent to hell. When Humaiun arrived, Bikermajit's people attempted to escape, but were taken by the parties which Humaiun had placed upon the watch and taken into custody.

"Of their own free will, they presented to Humaiun a tribute consisting of a quantity of jewels and precious stones. Among these was one famous diamond, which had been acquired by Sultan Ala-ud-din. It was so valuable that a judge of diamonds valued it at half the daily expenses of the whole world."

The stone remained in the possession of the Mughal emperors till Nadir Shah's invasion in 1739. It is said, when Nadir Shah seized the Delhi Treasury, this stone wasn't among the treasure, but he soon learned that the defeated emperor, Mohammed, had concealed it in his turban. Invoking an old Hindu custom, Nadir Shah suddenly proposed to Mohammed an exchange of turbans, in token of reconciliation. When Nadir unfolded the turban in the secrecy of his tent, he hailed the sudden revelation of the sparkling gem with the exclamation "Koh-i-noor"!, which means "mountain of light".

According to the *National Geographic* magazine, which had researched and found the above account of the gem's history, the Koh-i-noor had changed hands several times after Nadir, and several of its owners had lost the gem in horrible torture. Somehow, the gem came back to India and after the Sikh rebellion and annexation of the Punjab, the Koh-i-noor passed to the East India Company with the stipulation that it be presented to the Queen of England, Victoria.

The illustration (top left) shows it in its supposed original state — some 800 carats, for many hundreds of years the largest diamond in man's possession. After its first cut, it weighed 191 carats; in 1862, it was carelessly recut (top right) to 108 carats.

her against other surfaces or against elf. This property is made use of in e diamond stylus of record players.

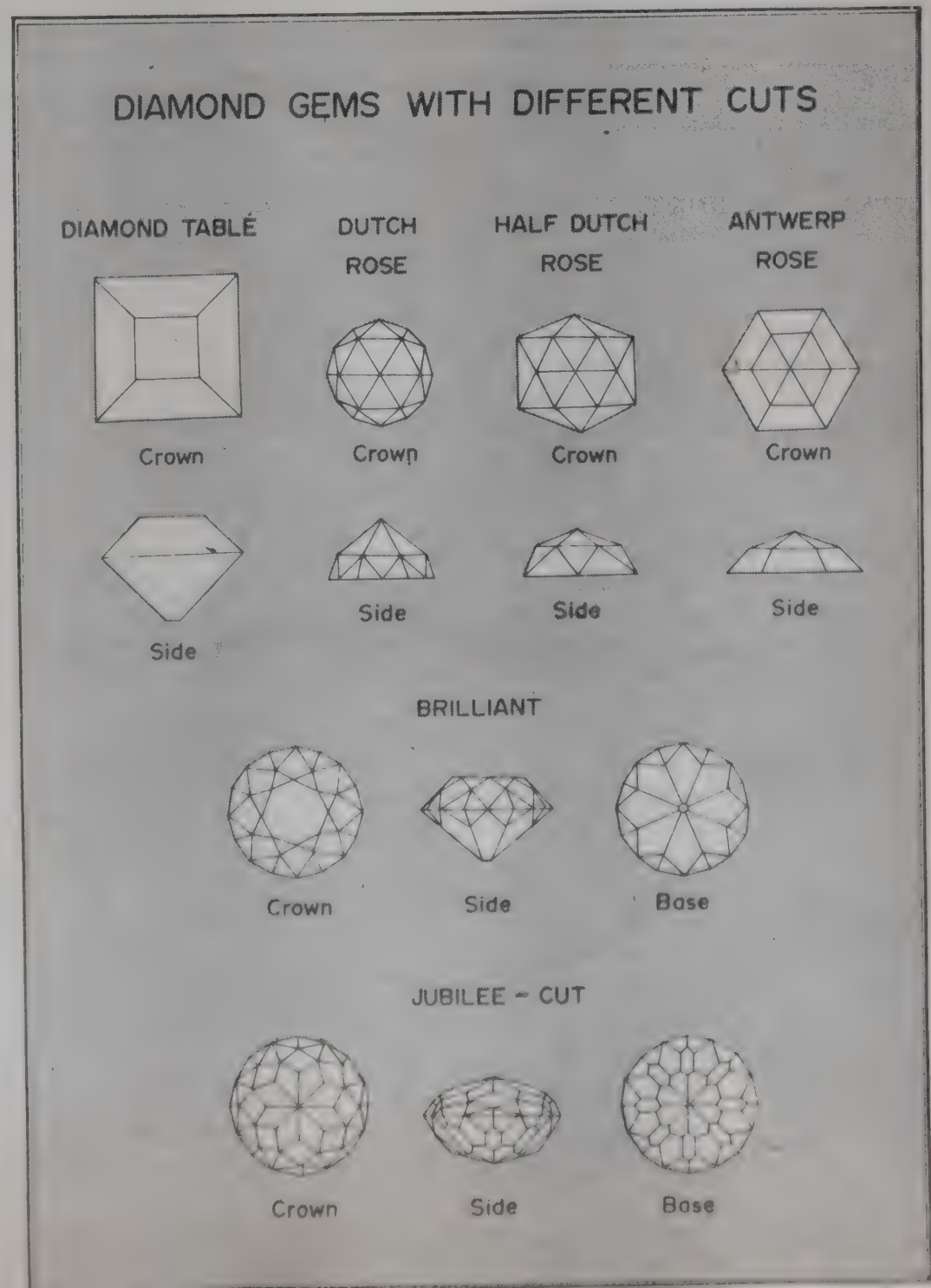
otical properties

What causes the lebrated "fire" of the diamond? hen light enters a solid or liquid om the air, it bends (or refracts) at e interface. This happens because e speed of light in the solid (or quid) is less than that in air. The tio of the speed of light in air to at in the solid (or liquid) is called e refractive index; for diamond, it exceptionally high, namely 2·4, mpared to 1·33 for water. And nce the reflecting power of a transarent surface depends on the refracve index, diamond possesses a high flecting capacity of 18 per cent — ·5 times that of glass. This is why, ght is strongly reflected by a well-olished diamond face.

But, then, diamond also possesses high dispersion. This means, it xhibits considerable difference in efraction for the different colours of ne spectrum. The refractive index or red in diamond is 2·407 and for iolet it is 2·465, the difference beween the two values being 0·058. s a result, when white light enters a iamond at an angle, it emerges with rilliant colours. This gives rise to the 'fire', which can be seen clearly if he diamond is moved slightly or if it illuminated by a flickering light, ay, from a candle. Diamonds are normally cut with faces set at carefully chosen angles such that when light enters the crystal, it finds a face which *totally reflects it back*. Any beam striking the diamond face at an angle exceeding 24· 5 degrees is totally reflected back, enhancing the "fire" of the diamond.

The birefringence (doubly refracting) property of diamonds had been studied by the late Prof. C. V. Raman (he spent a large share of his Nobel Prize money in the study of the peculiar optical characteristics of diamond) and his colleagues during 1944–47 and several other workers as well. Their research showed that the birefringence patterns exhibit bright parallel streaks attributable to oriented laminations inside the crystal — oriented parallel to octahedral or dodecahedral planes.

Unlike glass, diamond is transparent to X-rays. The colour and pattern of X-ray luminescence are less intense than those excited by ultraviolet rays. All diamonds show X-ray fluorescence, too, of blue and yellowish tinge, a little fainter compared to that of ultraviolet rays. Some diamonds show fluorescence in near ultraviolet (above 3,000 Å) while others respond to short ultraviolet rays (less than 3,000 Å). But only about 15 to 20 per cent of diamonds from the same source or deposit exhibit ultraviolet fluorescence. Thin diamonds, particularly the opaque varieties, reveal transmission up to 2,240 Å, the limit of the ultraviolet



Diamond Mining in India—Past and Present

An excellent account of the old diamond mines in South India is given in Tavernier's *Travels in India, vol. 2*. Tavernier, the French geographer, came to India several times in the 17th century and visited several producing mines in the Krishna river valley at Partiala in Krishna district and Kollur in Guntur district, where the diamonds were being recovered from the quaternary gravels formed by the Krishna river. He also visited the Ramallakota diamond mines in Kurnool district, where the diamond mines were located on the Banganapalle conglomerates. As per his account, about 40,000 workers were engaged in these mines (known as the 'Golkonda diamond mines' as the diamonds were then sold at Bhagyanagar — now Hyderabad — close to the famous Golkonda Fort). No account, however, is available about the production of individual mines. Jean Tavernier was, perhaps, unaware of the existence of diamond mining in that period at Panna in Bundelkhand district, at Sambalpur on the Mahanadi river and at Wairagarh in Chanda district. Apart from the above-mentioned localities in Andhra Pradesh, there are several others, totalling more than 80, where old diamond mines in the form of either open cast workings or some underground shafts and levels are seen even today.

An interesting account of diamond mining near Banganapalle and Munimadugu in the former Madras Presidency is available in the *Memoirs, vol. 5*, of William King of the Geological Survey of India, who visited the mining activity there during 1871. According to him, the diamonds found there were smaller in size than the diamonds found in the gravels of the Krishna river.

The Deccan Mining Company attempted to operate some mines at Partiala during 1896—1904 and was successful in recovering 2,334 carats of diamonds. However, the glorious diamond mining activity that prevailed in the Golkonda region for a few centuries declined gradually and almost ceased by 1906. The important reasons were: (*i*) Competition from new mines discovered in Brazil and South Africa after 1728; (*ii*) the poor incidence of diamonds in the gravels and conglomerates, resulting in higher cost of production; (*iii*) exhaustion of the gravel material from the rivers and lack of facilities to locate new subsurface gravels; (*iv*) lack of proper facilities to crush the hard conglomerates to recover the diamonds cemented in them as only the softer layers in the conglomerates at the bottom were treated by the ancient miners; (*v*) the political instability during the 18th and 19th century in this region; and (*vi*) inability of the then mine owners to recognise the primary source of diamonds as kimberlite volcanic pipes.

Since 1967, the Geological Survey of India (GSI) has started exploratory work for diamonds in parts of Andhra Pradesh in different host rocks such as (*i*) volcanic pipe rocks, (*ii*) older conglomerates ('Banganappalle' in AP and 'Rewa' in Panna, MP), and (*iii*) river gravels (old). The volcanic pipe rocks, agglomerates resembling the kimberlites of South Africa, are the primary source of diamonds. Six such volcanic pipes have been located near Vajrakarur and Lattavaram in the Anantapur district of Andhra Pradesh and three in the Panna area in Madhya Pradesh. The pipe at Vajrakarur has so far yielded 25 diamonds altogether weighing more than 25 carats, the largest being a gem of 9·4 carats. From the economic point of view, the incidence of diamonds in this pipe is rather erratic and poor. There is, however, the possibility of discovering new kimberlite pipes hidden under soil cover in the vast stretch of the crystalline schists and granites of this region. A tract of about 6,000 sq km near Guntakal yields a few diamonds during the rainy season when the land is furrowed for cultivation. These finds support the view that hidden pipes may exist in this region below the soil cover. Modern geophysical methods using both airborne and ground surveys could be utilised to locate the deposits, if they exist. (All volcanic pipes need not be diamondiferous, since we know that out of about 100 pipes in South Africa, only about six contain economically extractable diamonds.)

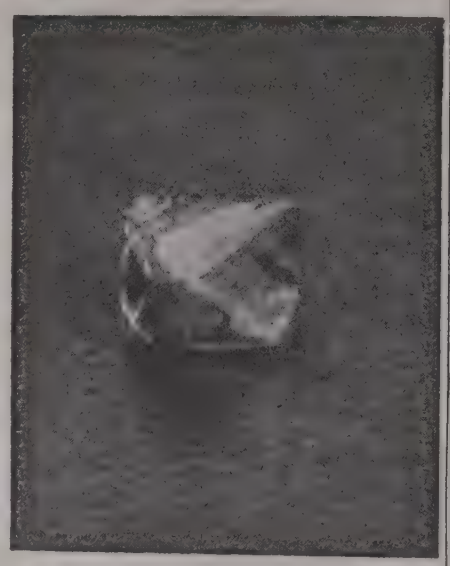
Andhra Pradesh also contains a tract of more than 3,000 sq km where the secondary source of diamonds, namely the Banganapalle conglomerates (about 600 to 800 million years old), are exposed in a series of hill ranges in the Kurnool district. These conglomerates derived their diamonds by the weathering and erosion of the kimberlitic pipes to the west of this area and then subsequent transport by the then-existing streams and rivers in the geological past. The numerous workings present here are restricted to the surface exposures of the conglomerates forming the plateau tops. Large tracts of the conglomerates under the cover of younger formations yet remain unexplored in the Cudd and Kurnool districts. Attempt exploratory mining in Ramallakota to recover diamonds from the 'Ban appalle conglomerate' by the Nati Mineral Development Corporation a few years ago were, however, pended due to the poor incidenc diamonds as well as their small (less than a carat).

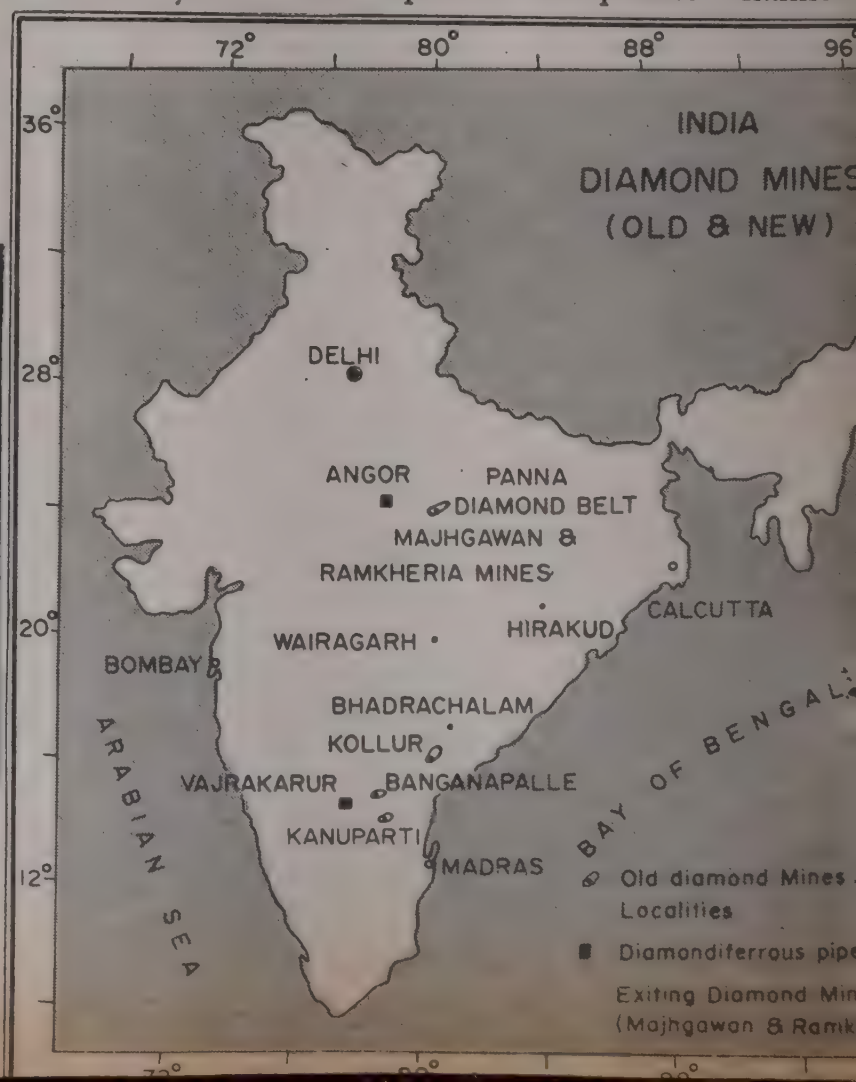
The gravel beds, comparatively m younger in age (less than one mi years old) belong to the Pleistocene Holocene geological periods. These are formed as a result of the denuda of the diamondiferous conglomerates kimberlites exposed in the catchm areas of the rivers and subsequent tr port and deposition of this materia the river channels and banks. In And Pradesh, the gravels found along beds of the Krishna, Pennar and Tun bhadra rivers have been worked recovery of diamonds. Some of ancient mines were located in the gra deposited in potholes (circular cavit in limestones lying in the bed of Tungabhadra river.

The ancient miners, however, confi their mining activities largely to Krishna and Pennar river basins whe from they recovered large diamo from abandoned channels, the gra constituting the older terraces. Th gravel beds, which occur within dep of 5 to 10 metres from the surface, fo a potential source amenable to e mining, treatment and recovery of gems, without the need for crushing a consequent breaking of the diamon The programme of exploration in th unconsolidated host rocks is natura based on a critical assessment of available background information abo the intensity of old diamond mines alo the Krishna valley, depths of workin amount of water available and t difficulties of open cast workings, etc.

The location of these workings studi with respect to the present channel

Fig. 6 (Below) 47.9 carat "Vijay", the largest 'chance' find at Panna (by a rustic named Rasul Muhammad), is valued at about Rs. 3,00,000





e river gives an idea of the fluctua-
ons of the stream in the past and aids
locating favourable sites, which can
confirmed by aerial and ground
rveys. These areas are then taken up
r drilling by ' hand augers '. Once the
b-surface gravel bed is picked up in
rtain holes, it is demarcated in all
rections by a series of holes. An area
44 sq km was covered by about 450
and auger boreholes during the period
etween 1967 and 1972 and five virgin
bsurface gravel patches were dis-
vered in the vicinity of Partiala area.
ulk samples from two of these gravel
atches yielded three diamonds weighing
2 carats, the biggest being a diamond
3·25 carats.

Diamonds should occur at a minimum
ncentration of 5 to 6 carats per
undred tonnes of host rock with at least
ne ' chance ' find of a big diamond over
) carats in a year if the mine is to be
conomical. If no chance finds are likely,
e minimum caratage should be about
n per hundred tonnes and the majority
the diamonds should be of gem
uality. The ratio of gems to industrials
also a factor to be considered in
e economics of a mine. The host rocks
diamonds show a wide variation in
iamond content, since there is a ten-
ency of clustering of diamonds in cer-
in portions of it. The recovery of
iamonds from mines is, therefore,
ratic and variable.

Another difficulty is that even after
xposure of host rocks, there may not be
ny direct surface indication of the
resence of diamonds. In such cases, the
ost rock is examined for the presence
paragenetic minerals (minerals
rmed with the diamond) which act as
path-finders ' for diamonds. These
inerals include picroilmenite, pyrope
arnet and chromediopside. In the case
hidden bodies, indirect methods like
eophysical and geochemical surveys
nd the study of paragenetic minerals in
tream sediments are resorted to during
itial stages of prospecting. Once a
imberlite, a conglomerate or a gravel
ed is located, further exploration con-
sts of excavation of the rock for bulk
reatment for the recovery of diamonds.

The sporadic attempts at mining in
he Panna area in Madhya Pradesh
round Majhgawan was the only source
f Indian diamonds till 1969. Later,
prospecting and systematic work in the
Majhgawan volcanic pipe, the Rewa
onglomerates and the gravels of Bagen
iver at Ramkheria led to the opening of
ystematic mining, treatment of material
nd recovery of diamonds, thereby
stablishing the only diamond producing
mines in India today. Two more pipes
namely the Angor and Hinota were
liscovered and proved to be diamondi-
erous. But the incidence of diamonds
eing poor, no diamond mines could be
pened at these sites. The discovery of a
imberlite dyke at Chelima in Andhra
Pradesh has also been reported. The
exploration work is still in progress in
the neighbourhood areas. M.L.D.

transparent type. The infrared absorption spectra of some diamonds, the non-luminescent type, are found to be completely non-absorbing in the frequency range 770 cm^{-1} to 1,400 cm^{-1}. The luminescent types show a band in this region with a number of absorption maxima.

There are a few diamonds, mostly the synthetic ones, which are highly transparent in the infrared and find application in defence in what are called infrared image converters.

When it comes to colour, colourless diamonds (sometimes known as " blue white ") are supposed to make the best gems, though coloured stones, usually pale yellow or smoky brown, are more commonly found. In fact, some beautifully coloured diamonds — known as " fancy stones " — are priced very highly; the Hope diamond is deep sapphire blue, the still costlier Dresden is green and the Tiffany diamond is a rich orange-yellow.

Yet, colour can be induced in colourless diamonds *artificially* by irradiation. By bombarding with neutrons from an atomic reactor or by charged particles from a cyclotron, diamonds of commercially undesirable yellowish tint can be turned green, and stones of brown or golden-yellow hue can be produced from these by subsequent careful heating. By electron bombardment, stones of distinctly blue or bluish-green colour can be obtained. The irradiation causes displacement of atoms in the diamond crystal, leaving gaps in its structure which thus affect the absorption of light. The colour of a diamond can also be changed to green by exposure to radium or its salts.

Fig. 7 Every known gem has its own refractive index. The refractometer shown above identifies the gem by the light it bends — by means of mirrors, lenses and a graduated scale. Another clue is the stone's specific gravity, or the stone's weight compared with that of an equal volume of water (measured with the balance seen in the background)

Thermal properties

Just as good conductors of electricity are also good conductors of heat, since both heat and electricity in a substance are conducted by means of free electrons, good insulators such as glass or porcelain are also poor conductors of heat. Yet, though diamonds (apart from one or two exceptionally rare blue diamonds) are very good electric insulators, surprisingly, they conduct heat extraordinarily well. The reason:

Deciphering diamonds from duds

A number of stones and substances may look like a diamond, but a trained person can easily distinguish a diamond from these substances due to its unique characteristics. The following properties of diamond are generally used in identification: *specific gravity = 3·2, Hardness = 10 on Moh's scale,* and *refractive index = 2·417.* Besides, a strong dispersion of light and adamantine lustre suggests diamond.

Colourless quartz looks like diamond but lacks the fire. White zircon, synthetic white sapphires and synthetic white spinel are often used as imitation diamonds. They are not easy to detect when small brilliant cut and baguette cut stones are used in imitation jewellery. Strontium titanate, sold as Fabulate and Diagem, is another diamond simulant. It has an unusual degree of fire but low hardness. Another substance is yttrium aluminium garnet (YAG) sold in the name of Diamonair and Cirolite, but it has less fire than diamond. Lithium niobite sold as Linobite has more fire than diamond but is soft.

If any doubling or rear-edge facets are seen, diamond can clearly be ruled out; the stone should either be zircon or lithium niobite. Glass stones and strontium titanate usually give a moulded look to the facet edges as compared to the sharp edges in diamonds. Strontium stones and synthetic sapphires show more fire than diamond, whereas synthetic spinel shows less fire. And the reflections from the table facet of diamond are sharp and undistorted but in other stones the images are slightly blurred. K.A.N.

Fig. 8 A handful of famous diamonds (shown on p. 40)? Believe it or not, all are perfect imitations made of quartz, owned by Giafomo Longo of Milan, Italy

the heat is not conducted in diamonds by free electrons but by types of crystal vibrations called phonons — a sort of wave propagating through the crystal.

This ability of diamonds to conduct heat is used by professionals as a test to distinguish genuine diamonds from fakes. The method is very simple. The object to be tested is kept on a table for sometime to attain room temperature. It is then picked up with a handkerchief and placed on the top of the tongue. The diamond feels cold like a metal because it conducts away heat. The fakes — either zircon, quartz or a specially dense kind of glass called "paste" — being poor thermal conductors remain warm to the feel of the tongue.

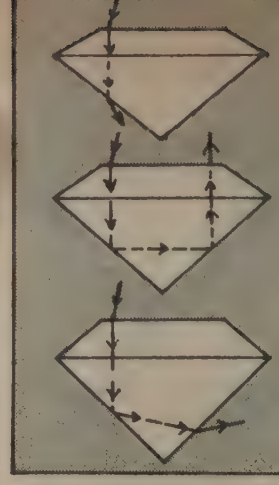


Fig. 9 How diamond cuts vary. All three have a one-carat spread, but the top figure shows a too shallow cut, the bottom figure a deep cut. The figure in the centre shows an 'ideal' cut

An even more remarkable thermal property of diamond is its exceptionally low coefficient of expansion. All bodies expand when heated, amongst the lowest expansion of material known to science is tha diamond — even less than the usually low-expanding metal in The two thermal properties — g heat conductivity and low expans — make diamond an ideal mate for machinery uses. Diamond tools used mainly as cutters and grinders do so much work that they get v hot; their excellent conductivity sures that the heat is dissipated a — to their metal matrix holders. A the low expansion property ensu that when used as a grinder or abrasive, the diamonds hardly di with the heat they retain.

Diamond cutting and polishing in India

The cutting and polishing of diamonds in India is mainly an export-oriented and labour-intensive cottage industry providing employment to more than a lakh of artisans and craftsmen. The industry is now mainly concentrated in the west coast of India at places such as Bhavnagar, Surat, Navsari, Bombay and in some parts of Kerala. The lapidaries in these places produce single cuts, brilliant cuts, baguette and marquise and also process other fancy shapes.

The industry still depends on dexterous and experienced hands and not machines (except a few firms in Bombay which have imported diamond-cutting machines). The cutting and polishing are carried out by means of simple tools. The imported rough diamonds (50 to 60 per cent of the roughs are imported from UK and the remaining from various sources such as the Antwerp open market) are first assorted quality-wise, size-wise and shape-wise. The diamond is then cleaved by means of a thin disc of relatively soft metal, whose edge is slightly indented. A single piece is slit into as many pieces as necessary, removing as many natural flaws as possible. The cleaved diamond is then cemented to a wooden stick for rough shaping against an emery or carborundum wheel. Having charged the lap with appropriate abrasives, the lapidiary first grinds the table facets. The other facets are then ground to their correct proportion and angles according to the design of the required cut. After the cutting is complete, the diamond is polished by means of diamond powder. Here master craftsmanship plays its part by correcting even a slight irregularity in the proportions left by the cutter. Polish imparts a brilliant finish and the diamond is ready for marketing after assortment.

Antwerp in Belgium is, however, the world's leader in cut and polished diamonds, the turnover approaching more than a billion dollars. The United States takes about 35 per cent of Belgium's total diamond exports. Next comes Israel, followed by India. Though Indian workers are said to far excel their European counterparts, especially in their skill in cutting the diamond, modern technology has enabled Belgium and Israel to outpace the Indian cutting industry in finish and output. For the smaller size diamonds we cut, use of semi-automatic dops would give a much larger output. For brutting, the Indian industry still uses centreless chuck lathes. However, for very large production, the Israelis and the Belgians have now adopted double-spindle lathes. For faster and rapid abrasion it is essential to evolve polishing benches with improved scaife cutting technology. Also for better and faster polishing of diamonds, the diamond powder collected during processing of rough diamonds has to b purified.

The rough diamonds polished i India at present are almost exclusively small in size and of a category known in the industry as "makeables". The Indian industry has gradually to shift and diversify from "makeables" to "sawables" for varied production and wider employment.

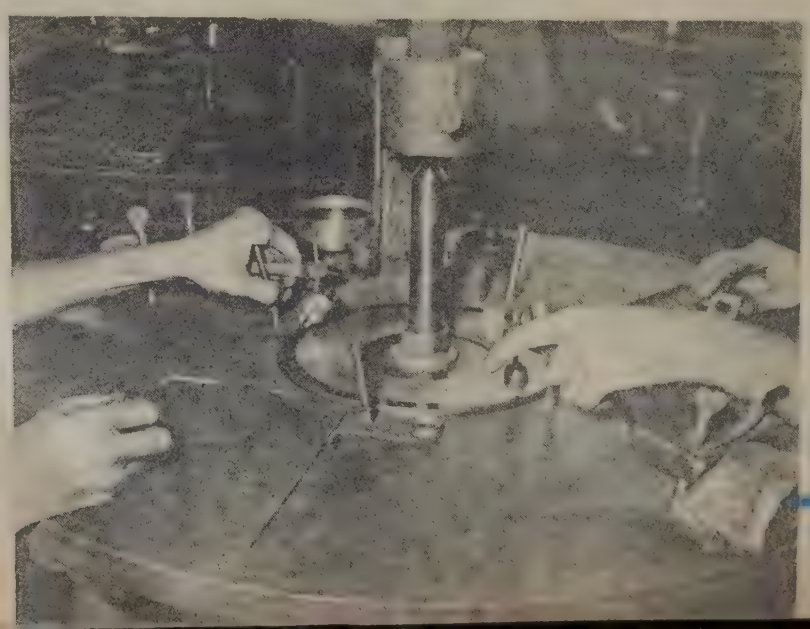
There is also need for better grading of diamonds. The value of a diamond is determined by four main characteristics, namely, its carat weight, cut, clarity and colour. Carat weight is determined by means of an electric balance accurately up to two places of decimals. Generally, the style of the cut and the proportions and symmetry of cut are not, at present, measured in the diamond business in India. However, a trained eye can easily detect the difference between an excellently cut diamond and a very badly cut one. (Correct proportions on a brilliant cut would give maximum brilliance; see Fig. 9.) When it comes to clarity, the standard technique used for detecting inclusions is to view the diamond in the morning in north light (light entering the room via a window facing north) by a 10× magnification hand-held lens. Every diamond of size greater than 0·03 carats is graded in India for clarity.

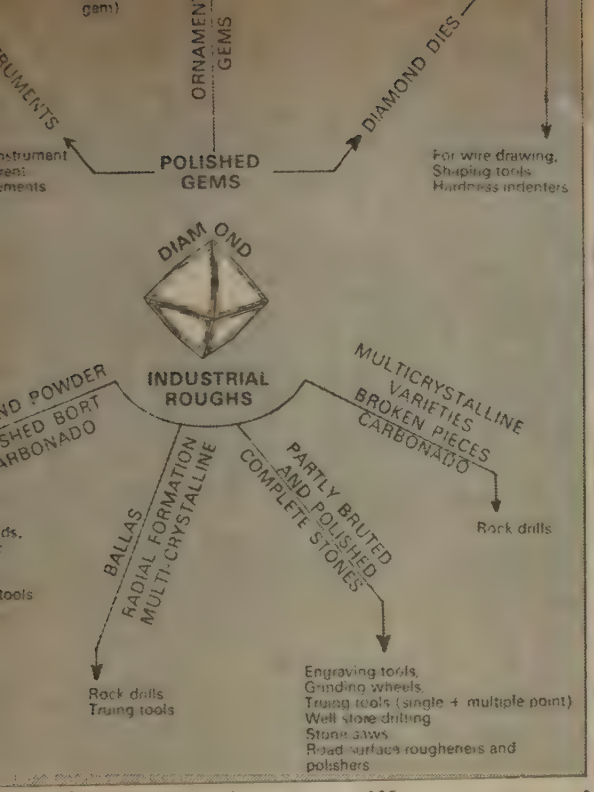
Colour grading is also done under north light with the diamond placed on a white background. The diamond under test is compared with a set of reference diamonds. The colours are graded as blue white, fine white, white, commercial white, light colour, etc.

The Indian diamond trade exported Rs. 231·05 crores worth of cut and polished diamonds in 1976-77. But it is regrettable that few facilities exist in the country for the testing and grading of diamonds using modern equipment and accessories. The only recognised laboratories are the Gem Testing Laboratory at Jaipur of the Gem and Jewellery Export Promotion Council and the laboratories of the Gemmological Institute of India at Bombay created by the Precious Stones Importers and Exporters' Association.

K.A.N.

Fig. 10 Two faces of diamond cutting in India. (Left) A cutter at work with archaic hand-controlled tools. (Right) Modern technology has come in the shape of 'dops' that hold the diamond against the polishing wheel which is coated with diamond powder





11 Chart showing the different uses of
nond

ustrial uses

Notwithstanding its
own as a gem, the industrial uses
diamond are so vast and varied that
diamond is now called the
nonarch " of modern industry. And
most important of its properties
de use of in industry is its hardness.
t is difficult to make an absolute
asurement of the hardness, but it
been indicated that the hardness
diamond is between 90 and 180
es that of corundum. Diamond,
refore, can cut diamond itself.
t and carbonado diamonds are
ticularly useful in industrial appli-
ions since the cleavage property of
ir individual crystals is masked by
ir crypto-crystalline structure, com-
ed essentially of minute interlock-
crystals of diamond, which makes
m extremely hard without the
dency to split under a heavy blow.
Diamond tools are used in shaping
internal combustion and diesel
gines. Bearings, particularly the
nze bearings in connected rods, are
ed by diamond drills for uniform
nensional accuracy and high finish.
e grinding wheel used in grinding
nponents to finished sizes are dia-
nd-trued; about 70 per cent of the
pply of bort goes into grinding
eels. The commutators of starter
tors and dynamos are machined
h diamond-tipped tools. Diamond
ls are also used in aircraft produc-
n, machine tool industries and
dely in glass and optical industries.
amond saws find an important
ce in cutting glass. They are also
d in free hand engraving in glass,
tting optical glass for lens and prism-
king and in bevelling and edge
nding of mirrors and table glass.
Diamond dies use industrial stones
drawing wire of a constant dia-
ter, normally less than one milli-

SYNTHETIC DIAMONDS

Although diamond-making had been a dream of alchemists for centuries, the first scientific attempts at diamond synthesis were not made until after 1797, when diamond was first shown to be a form of carbon. In the decades that followed, scientists in many countries tried — and failed — to convert carbon, an abundant and inexpensive substance, into diamond.

The work of Prof. P. W. Bridgman, an American physicist, on the production of very high pressure and its effects on various substances gave a special impetus to the production of synthetic substances. In 1951, the General Electric Company of America launched a major investigation into the effects of high temperatures and high pressures at its Research and Development Center in Schenectady, New York. And in 1955, came the news of the creation of tiny diamond crystals by a reproducible laboratory process. The transformation of graphite into diamond was accomplished by the action of a molten metal catalyst such as nickel and the simultaneous application of pressures of over 100,000 atmospheres (obtained by means of a giant hydraulic press) and temperatures of more than 2,500°C, in a very small pressure chamber; the process had to be repeated several times. The largest synthetic diamond produced was only 1·2 mm in length and about a thousandth of a carat in weight.

Most of the small synthetic diamonds are categorised as industrials. Man-made diamonds — because of their controlled properties tailored for specific industrial uses — have proved superior to natural diamond for many applications, and their production has been gradually stepped up during the past two decades. It is now estimated that over 16 million carats of synthetic diamonds are produced annually, mainly in the USA, the Ireland, Sweden, South Africa, Japan, USSR, Czechoslovakia and West Germany. The synthetic diamonds are made in grit sizes (0·1 mm), roughly octahedral in shape. Recently, it was reported that the National Physical Laboratory, Delhi, has been making attempts to produce synthetic diamonds.

The artificial production of gem diamonds — particularly of bigger size — is still more difficult. However, in 1970, the General Electric Company scientists announced that they had created gem diamonds in the laboratory, again subjecting graphite to extreme pressures and temperatures in a special apparatus. The process they used started with a seed crystal. This seed crystal, along with a metal catalyst and man-made diamond powder, was then subjected to high pressures and temperatures in a special press. The high temperatures melted the metal catalyst and dissolved the diamond powder. (The end of the chamber containing the seed crystal is kept cool enough so that the " seed " will not dissolve.) By carefully controlling the pressures and temperatures involved, the carbon atoms from the diamond powder were made to migrate through the molten catalyst and redeposit themselves upon the seed crystal, forming a large diamond. The process was long and complicated and took several days. The GEC scientists have also learnt to control the colour and clarity of the gem diamonds, as well as their ability to conduct heat and electricity by controlling the impurities in the growing crystal. However, synthesised, carat-sized gems are many times more expensive than mined diamonds.

M. L. D.

metre. Platinum alloy wire 0·00066 cm in diameter and tungsten wire 0·0007 cm in diameter used in lamps, radio tubes and electronic components are drawn through diamond dies. The diamond dies used for wire drawing must be free from inclusions and flaws.

Then, a large quantity of the industrial diamonds (bort and carbonado) are used as drilling bits. The diamond should be large enough to grind the grains of the rock formations and still allow sufficient space between the rock and the matrix for clearance. Diamond bits are also extensively used for drilling concrete and other man-made material, holes for pipes, cables, etc.

Diamond powder is produced not only from natural diamonds but from synthetic ones, too. It is mainly used as an abrasive for (*i*) sawing, rough polishing and fine polishing of gems and shaped tools; (*ii*) polishing tips of tungsten carbide tools; (*iii*) piercing, reboring and polishing of wire drawing dies; (*iv*) sizing and polishing of gramophone needles; and (*v*) lapping and polishing of hardened steel, gauges, metallographic specimens for microscopic studies, etc. The diamond powder is used in hones and hand laps in resin-bonded abrasive wheels. Electro-deposited tools are used in dentistry and electro-deposited grinding wheels, as cutting saws in ceramic, refractory, tiles and the glass industry.

To be honest, if we were to tabulate all the industrial uses of diamond, the list would easily run into tens of pages. And yet there are several other potential uses in various industries awaiting development.

Mr. Deshpande, a senior geologist with the Geological Survey of India, is Officer-in-charge of the Map Division, Central Region, at Nagpur. He has done exploratory work for diamonds in Andhra Pradesh, tin in MP and base metals in Karnataka.

HOW GOOD ARE OUR ELECTRICAL APPLIANCES

P. J. JOGLEKAR
S. T. PATIL

Of the various types of heating appliances, a room-heater is the simplest. The heat radiated by the heating element heats the surroundings. If there are preferred directions for the heat to be radiated, suitable reflectors can be used. The heating element is mounted such that no shock hazard is likely.

The next in complexity is the electric stove. Fairly simple in construction, it uses an open-type heater. Since it is used for cooking food, some care is necessary in its design to prevent the possibility of a shock. The toaster, on the other hand, is a handy appliance which serves a specific purpose. Since bread slices are inserted inside, precautions become necessary here also. Hot plates and irons provide various controls and are somewhat more complicated. Appliances used for heating water form a separate class. They need extra precaution.

The heart of a heating-type domestic electric appliance is a resistance wire, known as a heater element. It is usually made of an alloy of nickel and chromium, or iron and chromium, etc. The composition depends on the temperature it has to develop — without itself softening or melting. It also depends on the electric supply voltage on which it works. The most popular and commonly used wire is nickel-chromium, called " Nichrome ".

The Nichrome wire is available either as a normal round wire or as a flat ribbon. The normal percentages of nickel and chromium are 80/20 or 60/15 (the rest is mostly iron). The usual relationship between temperature and composition is: Nichrome 80/20, 1,200°C and Nichrome 60/15, 1,150°C.

The parts on which the heater element is supported or fixed must also withstand this high temperature and the supply voltage. Ceramic refractory materials like China clay, asbestos, mica and manganese-dioxide are the most commonly used materials. Which of these materials is used will depend on the type of appliance and how the heat generated is to be transferred efficiently.

The heating element is normally sealed within an insulating material which has a good capacity to conduct the heat from the element to the surface of the sealed unit. At the same time, the insulation has to keep the surface free from any leakage current or part of the supply voltage appearing thereon. This is vital for safety against hazards of electric shocks.

In hot plates and cooking ranges, the heater element is sealed inside metal discs, which are filled with insulating materials like mica, or asbestos sheets or powder. A further improvement is to put the heating element in a copper or brass tube and fill it with manganese-dioxide powder. This is a precision job and has to be done with automatic machines to ensure that the heater wire has maximum electrical resistance to the outer tube, but least thermal resistance for efficient heat transfer to the outer tube. This tube is then bent in a spiral shape to suit the size of the hot plate required. The heat transfer in this type of hot plates is far more efficient than in solid plates with embedded heater coils.

Heat transfer

This brings us to the problem of transfer of heat from the heating element to the surface of the appliance. Depending on the type of appliance, this heat is transferred either by radiation through air (as in ovens, toasters, room-heaters, gri etc) or by conduction through material with high electrical insu tion but good thermal conductivity capacity to conduct heat (as electric irons, hot plates, wa heaters, etc and, as mentioned earli refractory grade ceramics, mica shee asbestos papers or manganese-dioxi are used). While this transfer of he should be as efficient as possible, o has also to ensure that the heat is n wasted by conduction or radiation unwanted directions and ways. Radi tion in undesired directions can avoided by using heat reflectors as room-heaters. Wastage of heat conduction occurs in several ways through the hardware fixtures ar electrical connections. The heat dar ages the surface finish of the metal objects, that is, electroplating, pain ing, etc. It also burns the insulatio of the electrical wires connected to t heater elements. To minimise th damage, ceramic beads should be us on the electrical wires near the heat connections. Also, the wires use within the appliance of the heatin type should belong to insulation cla of B or H as far as possible. Th precaution will increase the life of th wires, which are subject to heat.

Temperature control

To use an applian efficiently, it is essential to control th heating. The control should be aut matic as well as fool-proof. He control in an electrical appliance

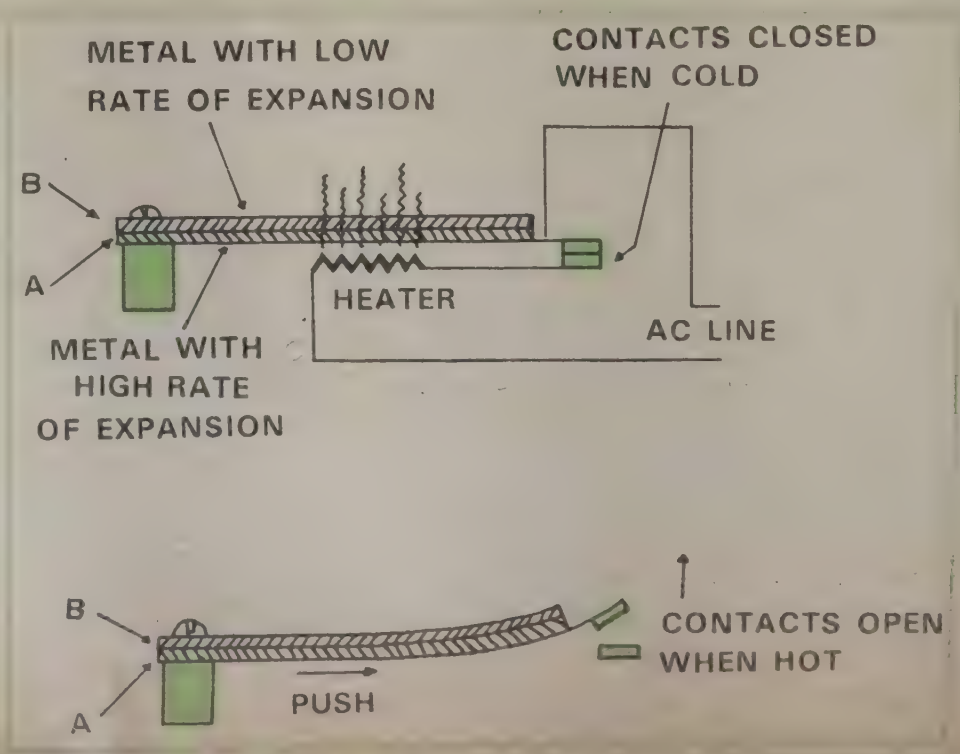


Fig. 1 A strip metals with dissim efficients of linear sion will bend wh heated. The defle proportional to the t ture to which the is heated. The resis the bimetal is su when a current through it, it gets and deflects to br circuit at point B B can be adjusted a temperature contro the heating is stopp bimetal gets straig makes the con again

t achieved by controlling the volt- and current. This is easier than trolling the heat generated. All nperature controls, therefore, either ulate the voltage and current or time during which the electrical rgy gets converted into heat in the stance wire.

n appliances like hot plates, ovens, the basic component for the trol of voltage/current is a switch h four positions. This is usually ieved by using one element, or separate heating elements, con- ted either in series or parallel. us, this switch enables one OFF three ON positions. In the low t (ON) position, the two elements connected in series to the mains pply; in the medium heat position, y one element is used and in the ximum heat position, the switch nects both elements in parallel.

It is possible to adjust the appliance that a particular temperature is not ceeded. The device which senses the nperature and actuates the electri- supply is known as a thermostat. is based on the bending of a netallic strip when heated (see g. 1). The thermostat will switch the electrical supply at a set tem- rature and will again resume it en the temperature drops by a few grees. There is a small range of nperature around the set value, thin which the thermostat will ulate the temperature. This range a measure of the thermostat's sitivity; the smaller this range, the re sensitive the appliance.

Thermostats are used in appliances e storage type water heaters and ner appliances of better quality such ovens, electric irons and washing chines with internal heating. e bimetal strip protects the elec- c circuits of the appliances. When a aximum rated current of an appli- ce is exceeded, the bimetal tem- rature reaches a level at which the pply is cut off. Such a device is lled a 'thermal cut-out'. (The inciple of thermostat is also used in pliances like toasters. But there the metal only switches off the current; does not switch it on, which is done anually.)

oltage and current transient aracteristics

Such protection is cessary because of the voltage and rrent transients — very sharp rises voltage or current over a very ort period of time. Transients are ely to occur, whenever there is a dden change in load conditions in e appliance or the neighbouring ectrical networks. When a high oltage circuit switches off a large current, there is a very high rise in voltage not only in the high-voltage network but also in the low-voltage distribution systems. This can give rise to a transient voltage in domestic supplies. Similarly, when an appliance is switched on full load, there is a sudden large inrush of current, which can be as high as 10 times the normal full load current (see SCIENCE TODAY, September 1977, p. 45). This is because of the fact that the resistance of a heater wire in cold condition is quite low compared to its resistance in hot condition. Not only the appliance or the heater element but also components like switches, connectors, wires, indicator lamps, etc should be designed to withstand such voltage and current transients. The voltage transient characteristics can be improved by the use of proper insulating materials. If the insulation level is marginal, then the voltage transients will affect the appliance.

To improve the current transient characteristics, the conductors must have an adequate rating. This avoids overheating of these parts even for short periods. Otherwise, the insulation of overheated parts will deteriorate and cause leakages, leading ultimately to a total breakdown of the insulation. In such an event, a short-circuit will occur or the full voltage will appear on the body of the appliance.

The electric stove

Though it is one of the simplest of appliances, the electric stove or oven is perhaps also one of the most hazardous. In fact, it should be banned from the market unless strict quality control is maintained. The heating element in an oven is a filament made from coiled Nichrome wire; it is accommodated in the grooves of a China clay plate (sometimes called brick). The ovens come in various designs in a wide price range. Several unauthorised manufacturers make it in its crudest form (Fig. 2) and there is always a possibility of a shock.

The heating element in an ordinary stove is just connected across the supply terminals by a two-pin connector. The element is embedded in a groove; normally it does not come in contact with the vessel kept on top. However, due to spillage of water or other liquid, the element gets burnt at some point or other. As it is possible to reconnect the broken filament, one may not find it necessary to throw it away. But in the process, the element gets loose and tends to bulge out of the groove, giving a shock. The element is then generally pushed back into the groove. With

Fig. 2 The electric stove. This is a crude design. The heating element is exposed, and a two-pin plug is used

further breaking and repair, the filament gets shorter and the wattage increases. (This may appear surprising at first. But since the length of the coil is reduced, its resistance is also reduced proportionately. Thus the element draws more current and consumes more power.) And if the connecting wires from the terminals to the heater element do not have the capacity to carry the excess current, they get overheated. Consequently, the insulation, or the wire itself, gets burnt. This causes a fault, which can be set right by replacing the connecting wires. What is worse is the possibility of one of the leads touching the body of the appliance, giving a shock. To avoid these hazards, the body of the stove should be earthed (see SCIENCE TODAY, September 1977, p. 45), and a hinged metal stand may be used to keep the vessels. The ISI specification lays down the various precautions.

Toaster

The toaster is a simple and efficient appliance, specifically for toasting sliced bread. Electric cooker grills can also make toasts, but they take a long time to warm up. For toasting one or two slices, toasters are quicker than the grills; for large quantities, say in excess of six, a grill is faster. Toasters come in two designs — the ordinary type in which the slice has to be taken out when done, and the automatic pop-up type where the toasted slice is thrown up automatically. The automatic type provides browning control, to give from pale to dark brown coloured toast. It also provides consistency in browning. However, if the browning control is based on time, the first slice would be less brown. And if you use a slice so thick that it needs to be pushed in or so thin that it curls when toasting, the pop-up mechanism may get jammed and the toast may catch fire. This can

further damage the insulation inside the toaster and affect its safety.

Since the pop-up toaster costs about thrice as much as an ordinary one, the ordinary type is more commonly used. But here there is a possibility of the toast burning if one is not attentive.

The mechanism provided at the bottom to remove crumbs from the collecting tray must be operated after disconnecting the mains. In some of the imported models, there is an interlocking mechanism such that one cannot clean without disconnecting. The crumbs create some peculiar problems; they usually attract cockroaches, and when the toaster is switched on, the cockroaches pop out before the toast, and occasionally, even after. One should never insert any metallic object like a spoon or a knife while the toaster is switched on.

In our survey, we did not come across a single toaster with ISI marking, though there is an ISI specification for the toaster. Most of the tests prescribed are general tests for safety requirement, with some minor specifications pertaining specially to the toaster. The only special test is the toasting test (see box on p. 49).

Hot plate

The heating elements in a hot plate are either embedded within a cast body (solid element) or enclosed within a tubular metallic sheath (sheathed elements). Since the element is thus enclosed, the shock hazard is greatly reduced. But the surface of the hot plate is exposed to the cooking ingredients through spillage. It is also likely to be subjected to temperature stress when cold water spills over it.

According to ISI standards, the thermal efficiency of the hot plate is expected to be at least 80 per cent. This is measured by finding out the electrical energy consumed to heat a specified quantity of water through a specified temperature difference under specified conditions.

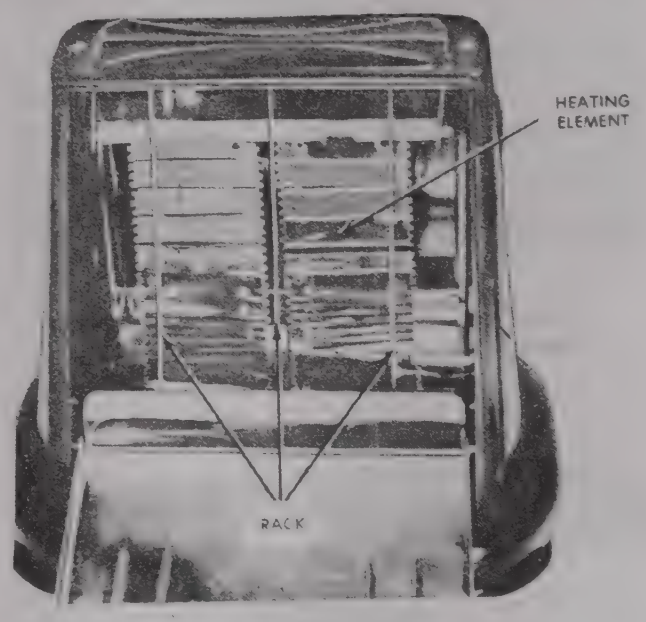
Electric iron

Electric irons are of two types: (1) automatic and (2) non-automatic. An automatic iron is fitted with a thermostat whose setting may be adjusted manually to alter the sole-plate temperature to suit different types of fabrics (see table below). Non-automatic irons just have a heating element and no control to adjust or limit the temperature.

FABRIC	TEMPERATURE (°C)
Nylon	70 to 90
Rayon	100 to 120
Silk	130 to 150
Wool	160 to 180
Cotton	200 to 220
Linen	230 to 260

The ISI lists two more types of irons: (1) iron with a self-resetting thermal cut-out, and (2) iron with a non-self resetting thermal cut-out. However, a survey showed that these types are not available in the mark Automatic irons are available Rs. 135, whereas the simple n automatic types are available Rs. 40. The manufacturers apparen feel that the iron should be eit very cheap or should provide sophisticated controls.

The ISI specifications stipulate t for irons without thermostat the te perature of the sole-plate is ma tained at 250°C ± 10°C by switchi the supply ON and OFF. In the n automatic type, this is done manua One has to be, therefore, careful ab the temperature, or the garment m get burnt. None of the irons availa in the market had ISI marks. T automatic types sell under establish brand names, while the ordina types are available under vario labels. On enquiry, it was found th this is a household industry, and o could buy in a lot and fix any lab Quality control, obviously, is a cry.



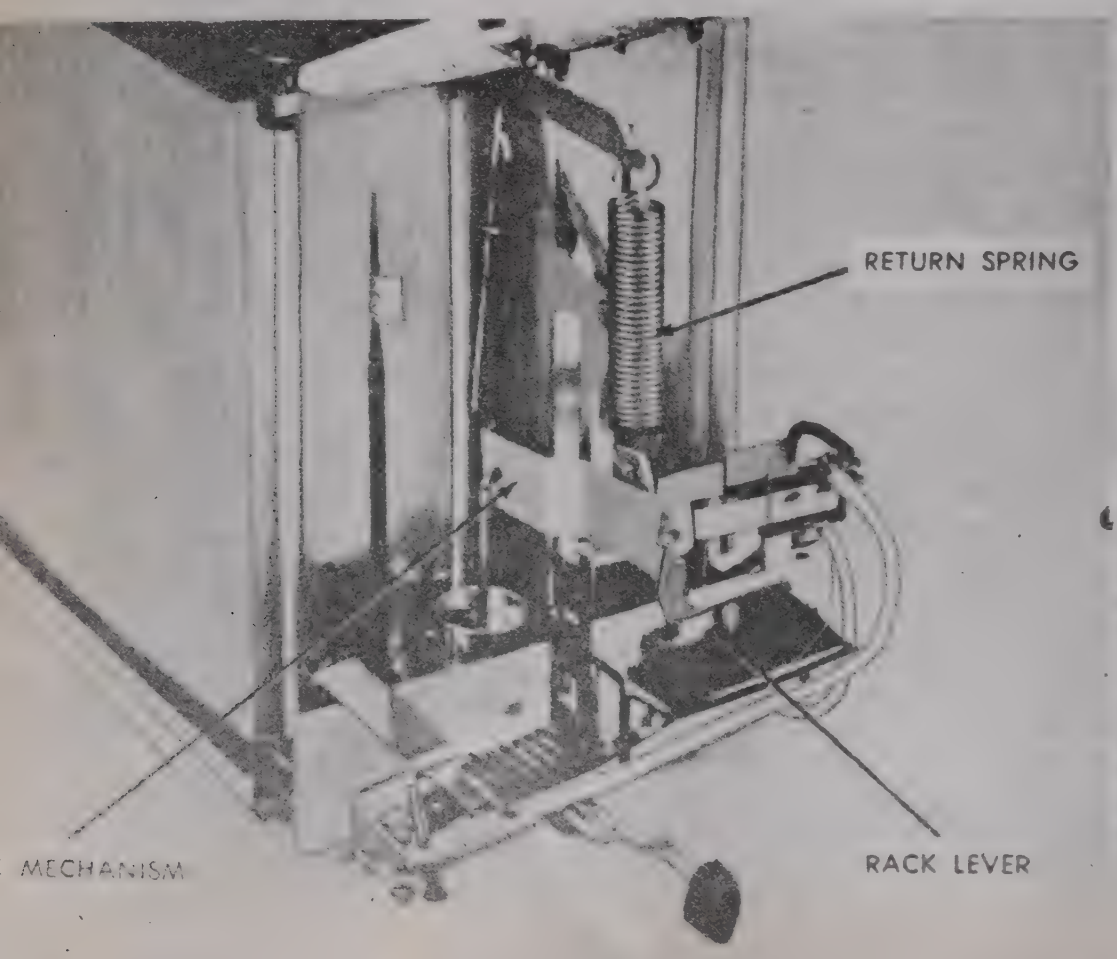


Fig. 3 (above) The non-automatic electric toaster with a lid open. The slice is placed against the rack

Fig. 4 (left) The mechanism of an automatic toaster. The lever actuates the switch and the timer

Water heaters

Basically, wat heaters are of two types — immersi and storage. Immersion type wat heater is also known as immersi rod (Fig. 6). It consists of (1) metal tube (of high conductivi material like copper or brass) co taining the heating element, (2) terminal housing made of bakeli (3) a three-core flexible cord, (4) water level indicator, and (5) a thre pin plug. Immersion water heate provide the most economical meth of heating water, both in terms of cost price and power consumptio But a sub-standard or a defecti immersion heater is also a potenti danger.

Immersion heaters are rated 1, 2 3 kW. The choice of rating, however, not so critical; the higher rating w heat up water faster. For heating particular quantity of water to t same temperature, the total electrici consumed will be approximately t same.

One of the common hazards immersion water heaters is leaka current; this is a result of the wat affecting the insulation. And if t earth connection is broken, it can gi a shock to a person standing barefo on the floor and dipping his hand the water to check the temperatur When the insulation is totally broke water can get charged with the f supply voltage, and a current pa through the human body to the we low resistance floor of the bathroo may give a fatal electric shock. Acc dents of this kind have occurr

HOW TO ENSURE QUALITY

The Indian Standards Institution standards specify three different test schedules — type tests, acceptance tests, and routine tests. The type tests are the most exhaustive; they include 20 to 30 tests covering the full range of performance requirements for a particular appliance, and are intended to check the basic design. The acceptance tests (usually about 10) are meant for inspecting a lot on a sampling basis. The routine tests (about five or six) are intended for 100 per cent inspection. They include visual inspection and safety tests.

We suggested last month that the Government order on compliance with ISI specifications should be implemented in a phased manner (see " The tug-of-war on quality ", SCIENCE TODAY, September 1977, p. 47). These phases could be (with minor modifications): (*i*) routine tests, (*ii*) acceptance tests, and (*iii*) type tests in that order. The routine tests do not require elaborate laboratory facilities, and can be provided in each major shopping centre. It would be fair to insist on this first phase implementation in about six months. It must be considered criminal on the part of anyone to manufacture or sell an appliance which does not meet the elementary requirements of safety.

Besides these routine tests, the ISI lays down specific tests for each type of appliance. What are these tests? For the toaster, for instance, the special test is called the toasting test. It specifies the size of the bread slice in numerical terms, but the result is only qualitative; it says that the browning should be even and of a reasonable texture and that it should not vary with supply voltage variations (within 5 per cent) or with the heating of the toaster. The endurance test prescribes that the toaster should be operated on a continuous cycle of heating (for three minutes) and cooling (for two minutes) for 500 hours. And at the end of the test, the toaster should be working satisfactorily.

For hot plates, the appliance is connected to the supply such that, with a specified vessel on the heating element, it takes 1·10 times the rated input. The endurance test consists of 500 cycles in which the hot plate is ON circuit for two hours and OFF circuit for two hours. During the test, 20 spillages each of 150 ml of 0·5 per cent solution of sodium chloride in distilled water at room temperature are made over the plate in one minute subject to the condition that (*i*) there shall not be more than four spillages in any 100 cycles, and these shall be equally spaced as nearly as possible over the time period, and (*ii*) alternate spillages shall be made on the plate in hot and cold conditions, that is, 15 minutes after switching on and 15 minutes after the switching off. Five minutes after each spillage, the hot plate should be subjected to a mechanical shock test by allowing a hardened steel ball of 75 mm diameter to drop freely six times from a height of 150 mm on to a 3 mm thick steel plate placed over the hot plate. At the end of the endurance test, the hot plate should be checked for proper functioning.

The routine tests for the electric iron include visual examination and inspection according to specifications for irons and other general tests. Other tests include measurement of heating up time and sole-plate temperature. The standards lay down that the heating up time should not exceed eight minutes. The specific tests include stability, cord guard, mass, measurement of temperature distribution, initial overswing temperature and heating up excess temperature (for thermostatic iron only), cyclic fluctuation of the hottest spot (for thermostatic iron only), temperature drop under load, mechanical strength, temperature rise and endurance.

Stability test for electric irons is meant to confirm that the iron does not overturn when tilted through 10°. The test for cord-guard is to check that neither the cord-guard nor the cord shows any damage through 20,000 flexing operations through an angle of 90°. The temperature distribution is measured at four specific points on the sole-plate. The temperature at any point should not differ from the mean by more than 6°C. For the measurements of (*i*) the initial overswing temperature, (*ii*) the heating up excess temperature, (*iii*) the cyclic fluctuation of temperature of the hottest point, and (*iv*) the temperature drop under load, elaborate procedures and apparatus are prescribed. However, no values are specified. Instead, the standards say that the values should be within the limits specified by the manufacturers. And that makes this portion of the test schedule redundant.

A drop test is also specified in which the iron, with the sole-plate horizontal, is dropped 1,000 times (a maximum of 20 falls from a height of 40 mm) on a steel plate, 15 mm thick and weighing at least 15 kg. During the test, the iron is operated and the sole-temperature is maintained as specified. After the test, a thermostatic iron should not change its calibration by more than + 10°C or — 20°C. The live parts should not be exposed by breakage or distortion of the enclosure. The temperature rise test is meant to determine the temperature rise of the rubber insulation of the internal and external wiring for which the limit is set at 40°C. In the endurance test, the iron is operated at 1·15 times the maximum rated input for 500 hours or 25,000 cycles of thermostat operation whichever occurs first. There should be no electrical or mechanical failures of the thermostat, nor any undue burning, pitting or welding of the contacts. The sole-plate temperature of an iron, with a thermostat, should not exceed 315°C average or a maximum of 350°C.

Special tests for storage water heaters include visual examination, pressure, mechanical strength, water capacity, input power, operating characteristics, abnormal operation and operation under overload conditions. Visual examination covers checking the quality of materials used, all seams and joints, sizes of inlet and outlet pipes, provision for draining, overflow, pressure regulating device, anti-drip device, inlet baffle, suitable labels and warnings of dangerous conditions.

But the most important one is the pressure test. For this, the container is subjected to twice the working pressure, subject to a minimum of 3·5 kg/cm² for the pressure type water heaters, and 0·8 kg/cm² for the free outlet type. The mechanical strength should be sufficient to withstand a load on top equivalent to the total weight of the heater plus water, when it is installed on a wall and filled full with water. The water capacity should not vary by less than 2·5 per cent or more than 10 per cent for the pressure type heater, and it should not be below 90 per cent of the stated capacity for the free outlet type heater.

The salient operating characteristics are the limits on idling losses, that is, the heat lost by conduction through lagging, check on calibration of the thermostat, overheating due to small frequent withdrawals of water, efficiency of the anti-drip device and diffusion performance. The abnormal operation tests consider events like short-circuit in the thermostat or heating on with no water in the container.

P.J.J.
S.T.P.

ery often. Compliance with the ISI andards, at least in respect of high oltage test, electrical resistance and oisture resistance tests are, therefore, n immediate necessity.

There are certain other problems, ke improper or inadequate chrome-plating, terminal housing made of non-electrical grade bakelite (thermosetting phenolic material) stuffed with a filler like saw dust, the use of cheap, sub-standard hardware resulting in the phase or earth wire getting disconnected, etc. When the plating of the copper tube containing the heating element is poor, the tube is subjected to faster corrosion, which ultimately leads to small holes in it. Once moisture or water enters this tube, the insulation starts deteriorating. While a number of brands of immersion

water heaters are available in the market, our survey showed that only one brand carried the ISI mark. The quality of the rest left much to be desired, and, hence, basic safety standards should be enforced.

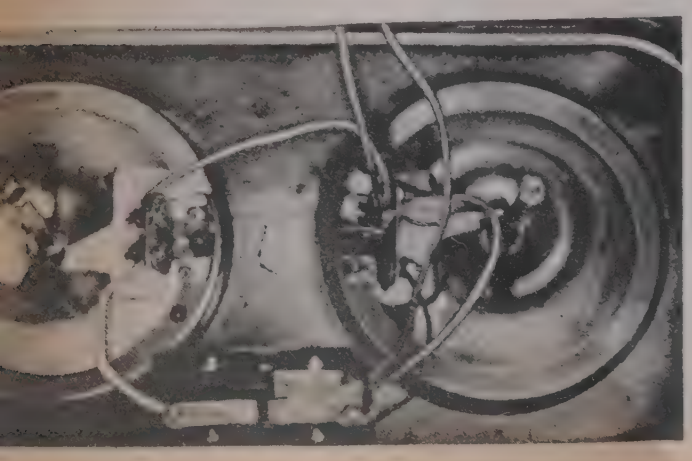
The most important precaution to be taken while using immersion heaters is that it should be dipped in water *before* switching the supply ON; before taking it out of water, the supply *must* be switched OFF. The same precaution should be followed even if one wants to put one's hand in the water to know how hot it is. The other precautions are: (1) the heater should be dipped in water only up to the indicated level and water should not be allowed to enter the terminal housing, (2) the heater should not be taken out of water immediately after switching off the supply, but allowed to cool down before taking it out; and (3) with hard water scales are formed on the metal tube, which should be periodically cleaned.

Storage type water heaters

Practically all storage type water heaters (Fig. 7) are automatic, that is, they are fitted with thermostats which control the water temperature. The temperature ranges from 32°C to 85°C. Storage type heaters are available in two versions — the displacement water type and the falling water level type. In the first version, hot water flows out when cold water is let in. The second type has an outlet valve at the bottom, and when opened, the water level inside drops as the water flows out. The former is more common and popular; it is also safer. In the falling water level type, there is a chance that if cold water is not filled after drawing hot water and the heating is left ON, steam may form inside and the pressure may damage the container.

The displacement water heater has two further variations — the pressure type or the controlled outlet type, and the free outlet type. In the pressure type, a valve fitted on the outlet water pipe controls the outflow of hot water. Because of this, the pressure inside the container is high and, if not controlled by means of a highly reliable thermostat and fitted with a good quality pressure safety valve, it can burst the heater and cause a serious accident. The free outlet type, has a valve in the inlet water pipe and the outlet pipe is free and open. And the outflow of hot water is controlled by the cold water inflow.

Fig. 5 The hot plate where the heating elements are sealed



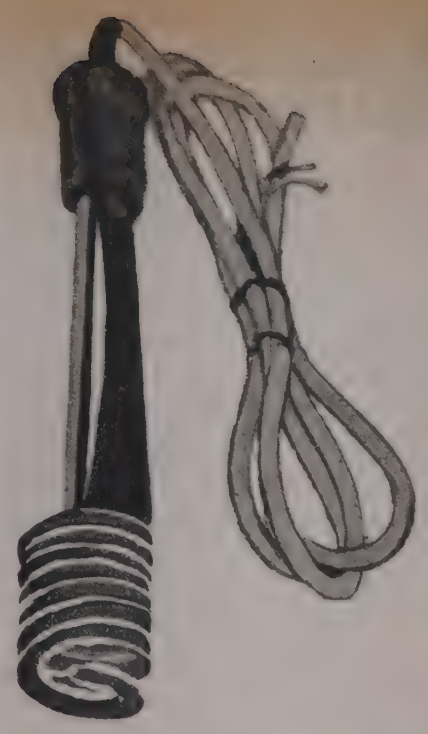
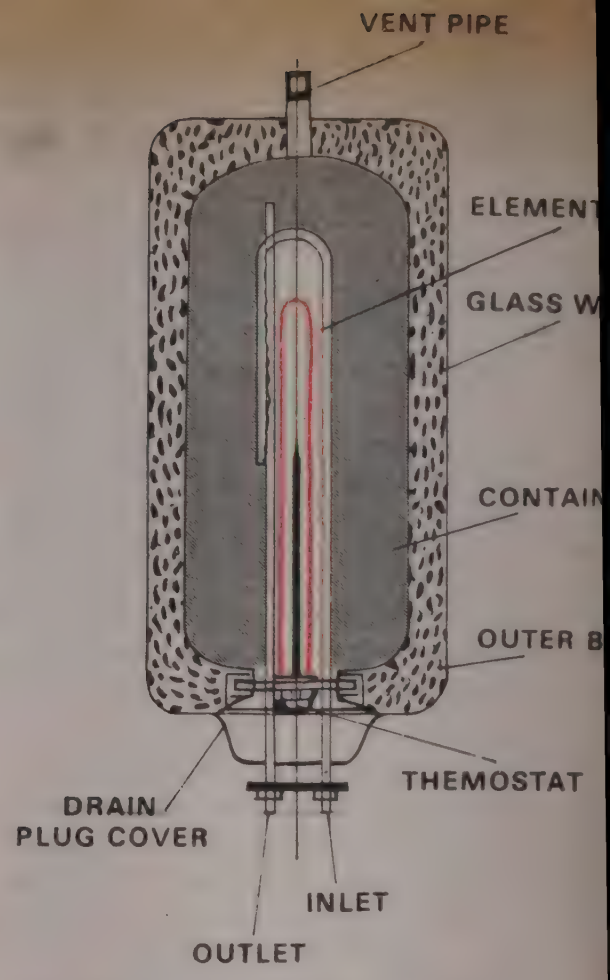


Fig. 6 (right) The immersion water heater

Fig. 7 (far right) A storage type water heater. The main parts are (1) a water container made of heavy gauge copper sheet of more than 90 per cent purity, (2) apparatus plate carrying the heating elements and thermostat, (3) outer body of mild steel sheet (of such thickness that the weight of the entire heater is supported by it rigidly), (4) a vent pipe or a pressure safety valve at the top, (5) glass wool, (6) drain valve to remove the dirt and the scales, and (7) pilot lamp indicator



The rated input of storage type heaters is between 1 and 5 kW, depending on the heater capacity which ranges from 6 to 200 litres. The electrical input for a particular water capacity depends, to some extent, on how quick the water needs to be heated, and to a larger extent, on the type of use. For example, when hot water is required for bath by several persons in quick succession, a larger electrical rating would be necessary. On the other hand, if the hot water is required throughout the day for kitchen use, a lower electrical rating is advantageous.

But it is important to have proper "lagging" — the thermal insulation of glass wool used in storage heaters — particularly if one is keeping the heater ON throughout the day. This will keep down heat losses from the hot water and thus save on power consumption. The simple way to check the quality of lagging is to touch the outer body of the heater by hand; if one feels the heat coming through to the outer surface, it is not as good as it should be.

A common question faced by storage water heater users is whether the heater should be switched off after use or left on. The answer is 'switch off', if one requires hot water only for baths, in which case the thermostat is set at the highest temperature. It is not worth switching off, if one requires water frequently and that too at short notice.

There is a vital factor to be co sidered while fitting a pressure ty storage heater. It is the head of wat or the pressure of water in the in pipe. If the inlet pipe is connected the storage tank without any val or tap, the pressure in the contain can be dangerously high and it m develop leakages or even explod Such accidents have occurred, thou rarely. In such cases, a pressu regulating valve (similar in functi to that fitted on the cooking g cylinder) should be used on the in pipe. The valve regulates the pressu at the heater inlet pipe over a wid range of water head pressure.

Such a situation as mentioned abo is a consequence of lack of awarene on the part of the consumers a indifference on the part of the man facturers and suppliers. Somewhe in the product leaflet the maximu permissible inlet water pressure m have been stated, but an average us may not know its implications. T sale and installation of safety devic like pressure safety valves and pre sure regulator valves in the inlet pi must, therefore, be made obligator Pressure regulator valves are par cularly necessary in high-rise apar ments, where the water storage ta is invariably on the terrace, givi rise to a high pressure.

There are about four well-kno brands of water heaters in the mark None apparently conforms to I standards, and it is doubtful if ev the barest, but most essential, tests a carried out.

The authors acknowledge: Figs. 1, 2, 3 and 5 from *How to Repair Small Applian* (Vol. 1), by Jack Darr, D. B. Taraporeva Sons & Co Private Ltd, Bombay and Figs and 7 from *Electrical Appliances Repair a Maintenance* by K. Nath, Hind Pocket Boo Pvt Ltd, Delhi.

...am while you play—12

D. KELKAR
V. DESHINGKAR

ast month we had ended our trip through the world of light with mirages — the illusory es of things seen not where actually are. But mirages not the only instances of 's tricks. We see so many of around us (in fact, we make of many of them) that we to take most of them for ted. Let's take the simplest nem — the apparent change ie size of things seen.

you dip a spoon into a glass water, the dipped portion bigger than the actual Why does the enlargement ease or decrease if you the spoon's position forward backward? The answer, of se, lies in the behaviour of s. A lens is a transparent ium — usually glass — that s down a beam of light ing through it and thus ds it.

Why should this slowing down ght rays make it easier to see gs? Or, to put it another way, t magic lies in a piece of glass brings out the teeming life drop of water as in a micro-e, or the distant stars a little er to the astronomer's eyes ing through a telescope, or es the blur of a distant object denly take a clear shape ugh the spectacles of a myopic hort-sighted person?

he clue to this magic is held 'refraction' — the bending ght rays as they pass through transparent media of diffe- densities. The reduction in speed of light (as light rays from air into the glass) is ompanied by a bending of the t rays; this occurs again as rays emerge from the glass the air and enter our eyes. he case of ordinary glass, the 'bendings' balance. But in ns, the two sides of the glass ground to an angle which es the rays travel off in a new ction. In a magnifying glass he simplest form of lens, per- s — this 'deceitful' bending light rays is deliberately ieved to make it appear as if

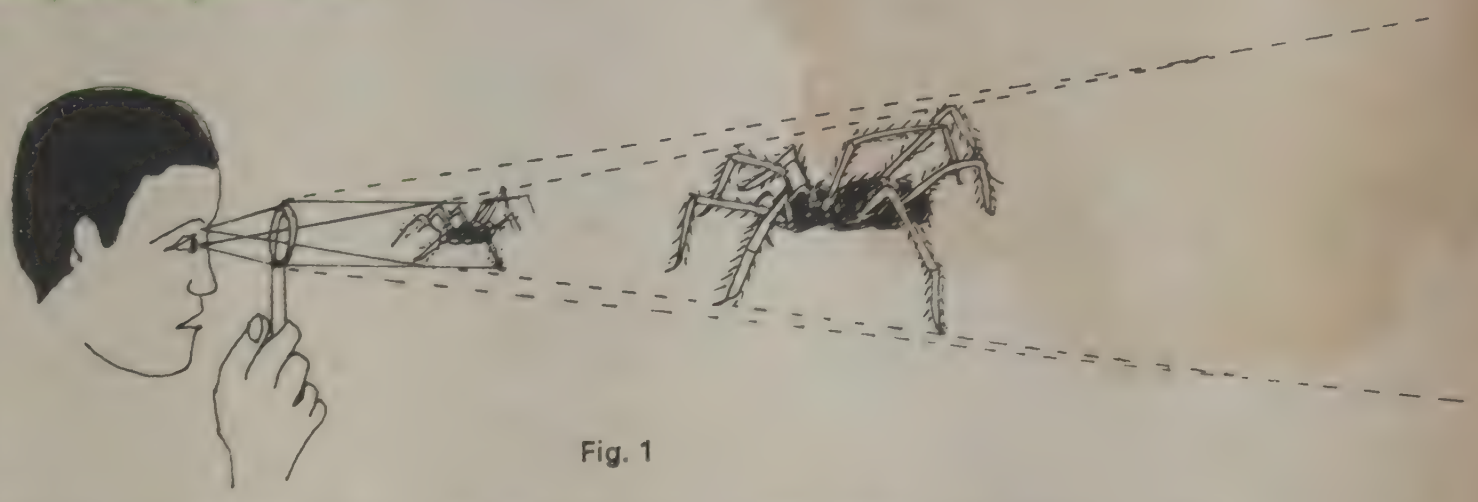


Fig. 1

they are coming from a closer or larger object (Fig. 1).

A magnifying glass has two sides curved such that it is thickest in the middle; it is known as a double-convex lens. Another type of lens — thinnest at the centre — is known as double-concave lens. If one side is flat and the other concave or convex, the term is plano-concave or plano-convex, as the case may be. Actually, to understand how light rays bend in a lens of convex or concave curvature, all we have to do is get hold of a pair of prisms. A convex lens, then, would be similar to the pair of prisms placed base to base (Fig. 2). When parallel beams fall on the set of prisms, the rays bend towards the base; they will meet at the focus F which is on their common axis. And that's exactly what happens in the case of a convex lens. On the other hand, a concave lens is like the pair of prisms placed apex to apex (Fig. 3). Here, too, the rays bend towards the base, that is, diverge outwards, and when traced back will appear to meet at the focus F.

The image seen through a concave lens appears smaller than the actual size. Fig. 4 shows why. Now take a convex lens and view an object through it by placing the lens at different distances from it. Here you will see a curious phenomenon: the object will be seen either upright and enlarged or inverted and reduced (Fig. 5). If you study the diagram, you will see that to get a magnified view, the object must be *inside* the focus of the lens. You can easily verify this. Hold the lens in a darkened room and let light from a window shine through it on to a piece of plane paper. You can see a small image of the window and the objects outside on the paper. Of course, the paper must be held at the correct distance, for example, for nearby objects, the paper must be farther away from the lens. You will notice the image on the paper is upside down (Fig. 6). And, that is the principle of the photographic camera (Fig. 7).

A magnifying glass focuses not only the visible rays but also the

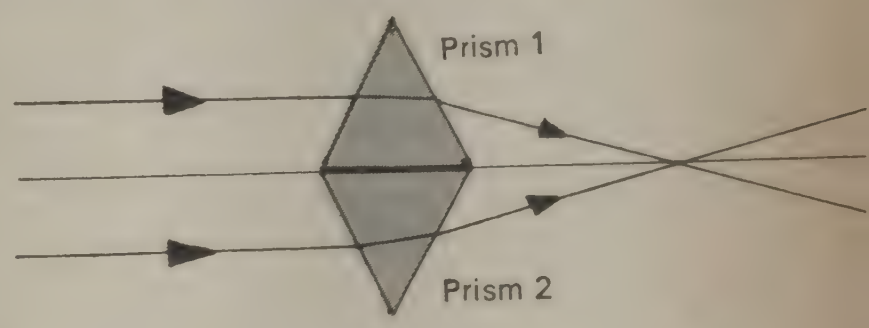


Fig. 2

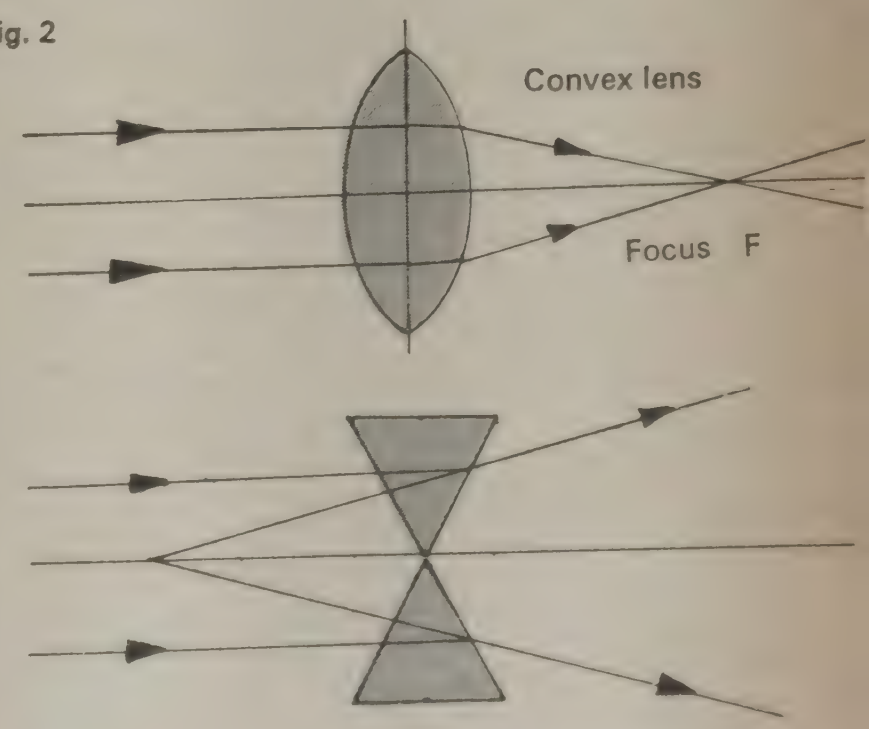
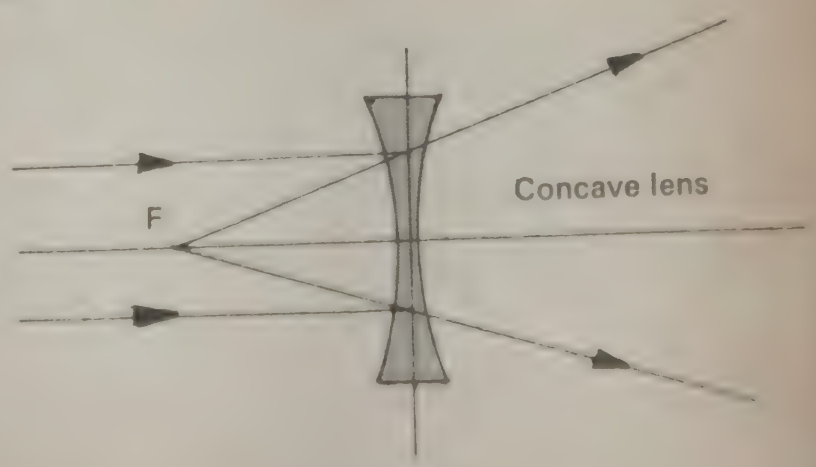


Fig. 3



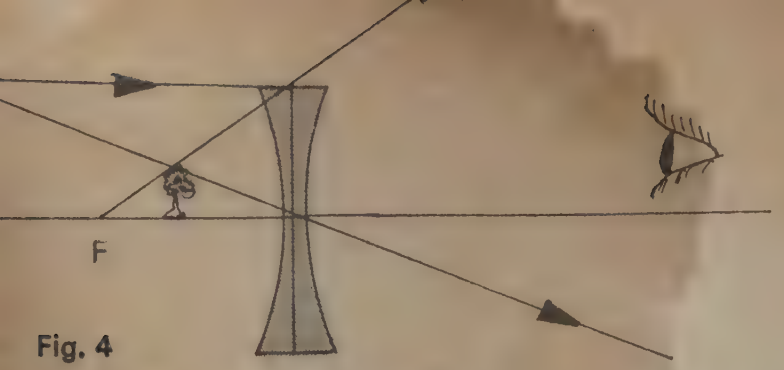


Fig. 4

invisible infra-red heat radiations. It can be proved easily. Hold a lens between the Sun and a piece of paper. First a small point will appear on the paper (this is the image of the Sun) and in a few minutes the paper will catch fire at that spot. This is why this sort of lens used to be known earlier as ' burning glass,' ' converging lens ', etc.

The distance between the paper and the lens in Fig. 6 is known as

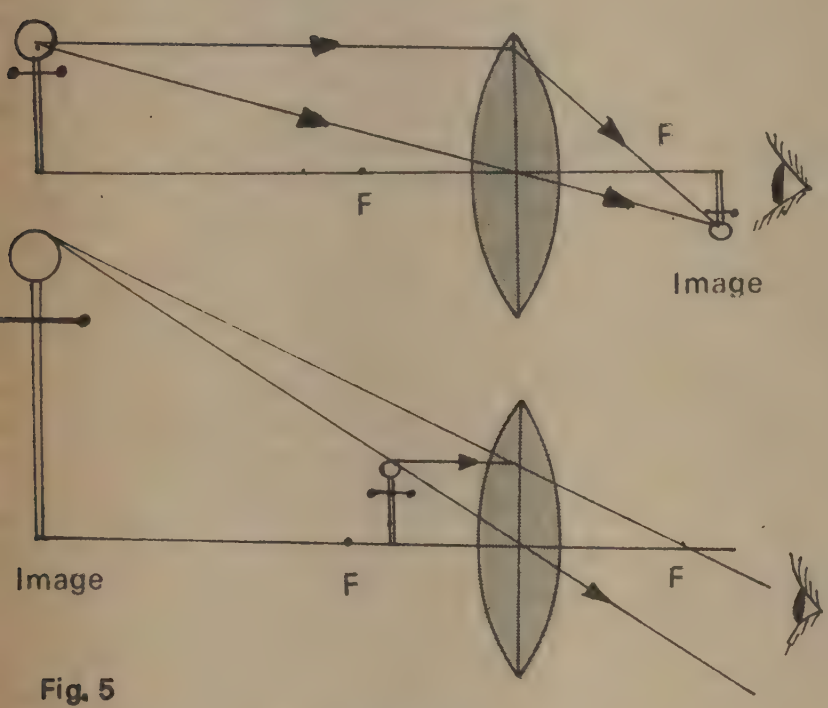


Fig. 5

the ' focal distance ' and depends on the curvature of the lens's sides. The human eye, too, has a lens and it has the remarkable ability to shape its sides to sharper or flatter curvature to adjust to the necessary focal distance. In the human eye (see box for a detailed description of its parts), the lens is attached to the inner walls of the eyeball by fine suspensory fibres. These fibres are normally held tight; if they are loosened, the eyeball becomes rounder, and the rounder the lens the shorter its focus. While looking at distant objects, we do not need to change the shape of the eye lens, but to see nearby objects, we have to alter the lens shape by loosening the suspensory fibres (by moving the ciliary muscles). This is called " accomodation ".

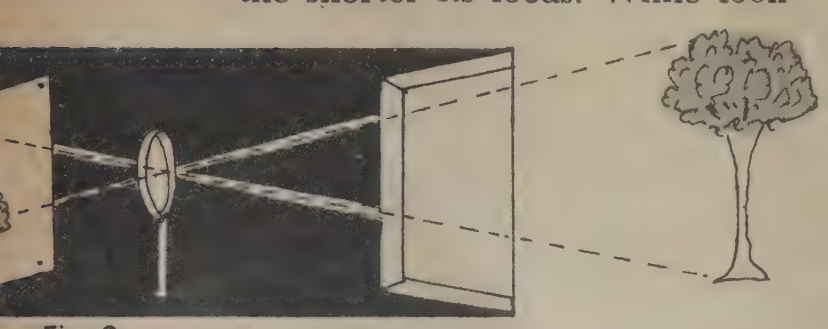
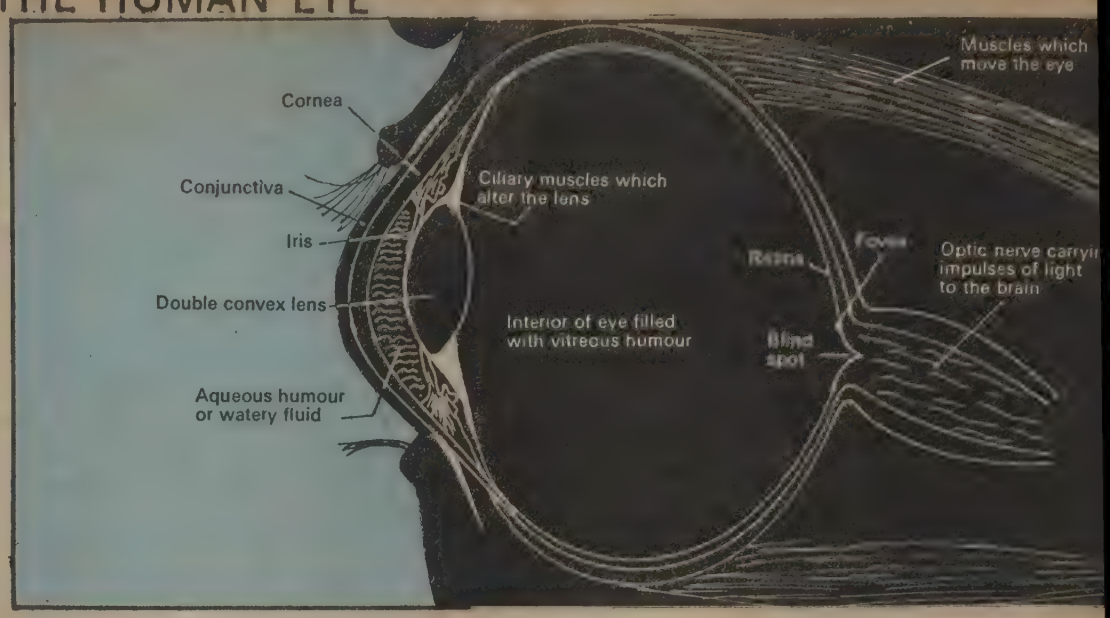


Fig. 6

But, then, not all eyes can adjust their vision by accomodation alone. There is the long-sighted person whose eyeballs are smaller than normal, which means the retina is a little too close to the lens; as a result, light rays focus behind the retina. The short-sighted person has eyeballs slightly larger than normal so that light rays focus at a point ahead of the retina. Fig. 8 shows how spectacles of different len curvatures correct these focusin defects.

Fig. 7

THE HUMAN EYE



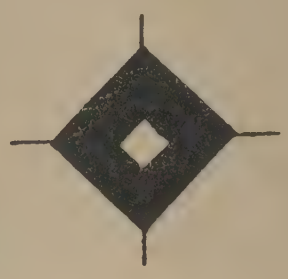
Optically, the eye is like an exceptionally fine camera with an elaborate lens system on one side and a sensitive screen known as the retina on the other. Light rays from objects pass through the refractive media of the cornea, the aqueous humour, a crystalline lens and the vitreous humour and are focused on the retina. The iris diaphragm opens wider for faint light and closes down to a pinhole for very bright light.

In the retina, light pulses are received by tiny cones and rods whose function, it appears, is to change the light into electrical impulses. Each cone and rod is connected with an individual nerve to conduct the impulses to the brain. How these electrical impulses are produced by the cell-like structure of cones and rods and how the impulses are interpreted by the brain are still not fully understood. It appears that the cones respond only to bright light and are particularly responsible for the determination and distinction of colour, whereas, the ro are sensitive to feeble light and v slight variations in the intensity.

At the very centre of the retina i small yellowish spot called the fov This small region contains a lar number of cones but no rods. Ne the fovea on the retina is a sm region called the ' blind spot '. T spot is insensitive to light.

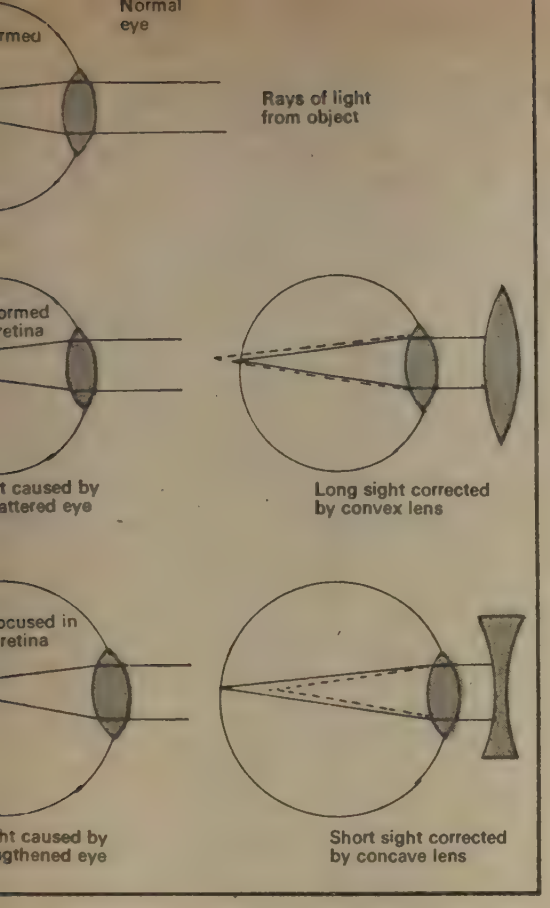
We can easily verify the existen of the blind spot. Look at the drawi below. Close your right eye and ho the page at an arm's length and lo at the circle with your left eye. Y can see both the circle and the squa from this distance. Now bring the pa slowly towards yourself with the l eye still fixed on the circle. When t drawing is about 25 cm from the ey the square disappears.

Repeat this experiment with the l eye closed and the right eye focused the square. As you bring the drawi closer, this time the circle will disappe



Optical illusions

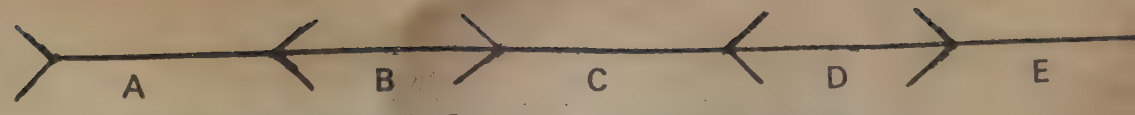
How reliable our vision? Visual informatio comes through the light reflecte by objects which enters the ey and reaches the retina. But tha is only one part of the ' seeing activity. The brain must interpre this information and this is wher it may fail to perform correctly Distances are misjudged, shape are distorted, and even we ten to see things that are not there The chief reason behind suc



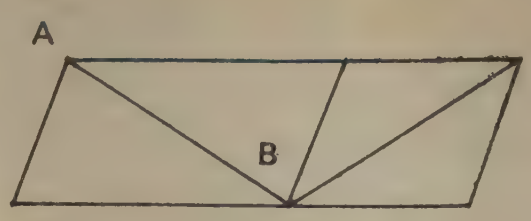
usions lies in our unreliable nse of perspective — that is, nat we *believe* to be the relation-ip between size and distance. number of such optical illusions some very famous — are shown the following pages. You can end hours on them and, if you sh, confound your friends with em. And you may try to work t what gives rise to these illu-ns. To be honest, many of these usions can be found reproduced textbooks of psychology. Many ychologists believe our ability interpret shapes and sizes is nditioned by the environment which we are brought up.

There is also the illusion of ovement that can be created moving different images in pid succession. A simple experi-ent is shown in Fig. 9. On one le of a cardboard is a picture a cage and on the other side is e picture of a bird. If you tate the cardboard fast enough y suspending it from a thread), e bird will appear to be inside

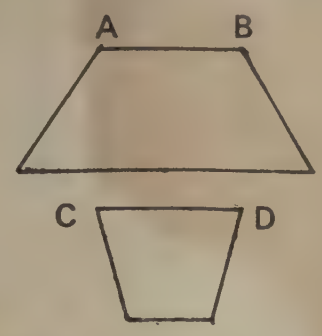
OPTICAL ILLUSIONS



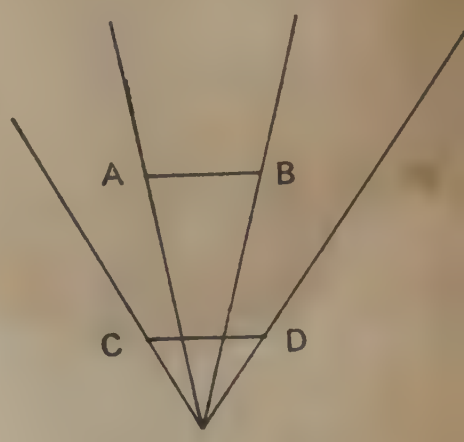
Are the segments A, B, C, D and E of the same length?

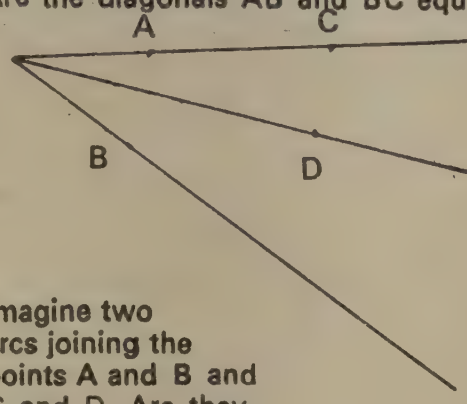


Are the diagonals AB and BC equal?

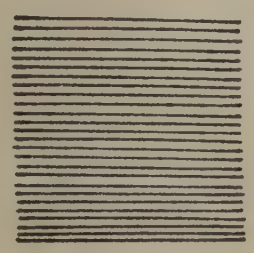


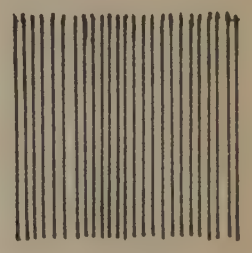
Is AB equal to CD in these two figures?





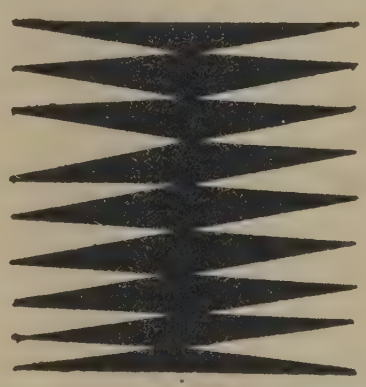
Imagine two arcs joining the points A and B and C and D. Are they equal?



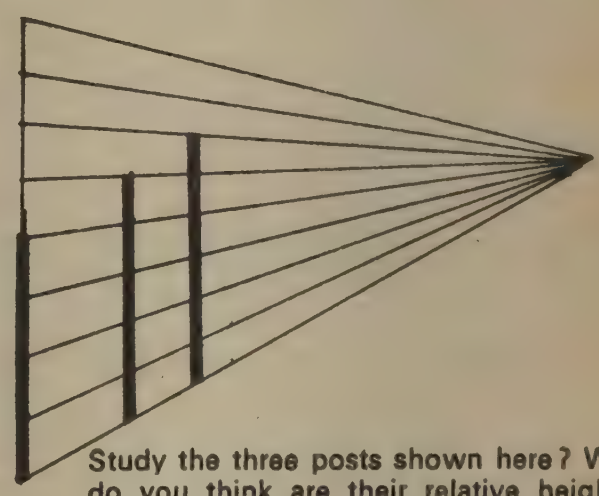


A B

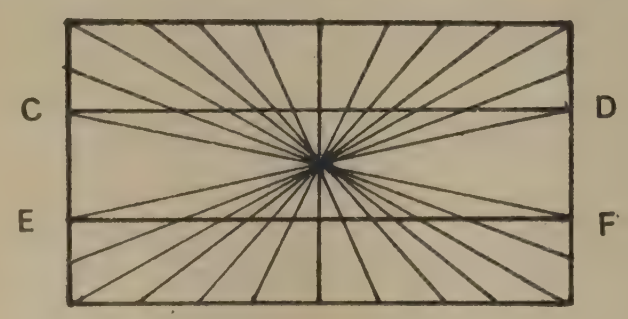
Two piles of parallel lines are shown here. Do you think the width of pile A is the same as that of B?

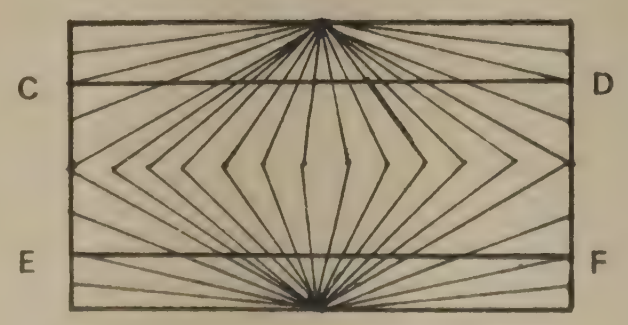


Look at this pile of diamond-shaped figures. Do you think the height of the pile is the same as its width?

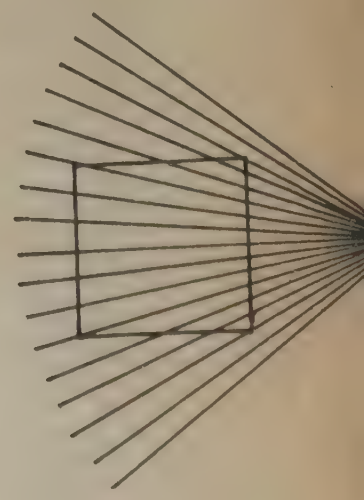


Study the three posts shown here? What do you think are their relative heights? Now verify by measuring them with a scale.



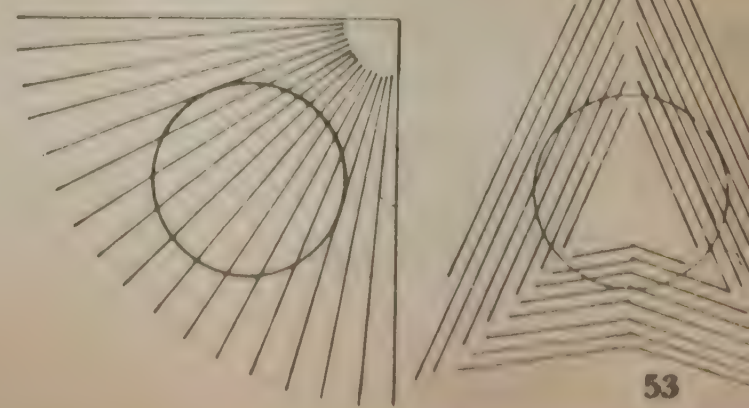


In both figures, lines CD and EF are parallel.

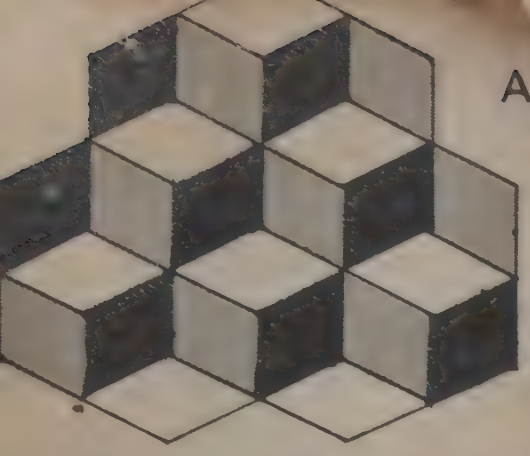


These two figures show how distorted appearance of regular geometrical figures is achieved by modes of surrounding lines. Above, both are perfect squares; below, both are perfect circles.

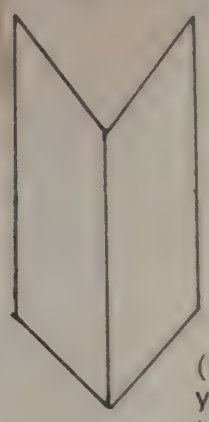
Hold the page and move your hand rapidly in circles and the gear wheel will seem to rotate in the opposite direction.

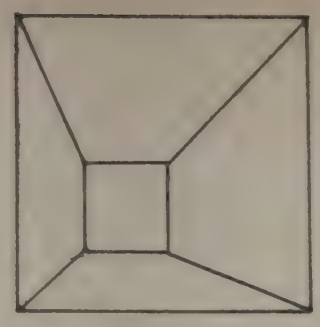


AMBIGUOUS IMAGES

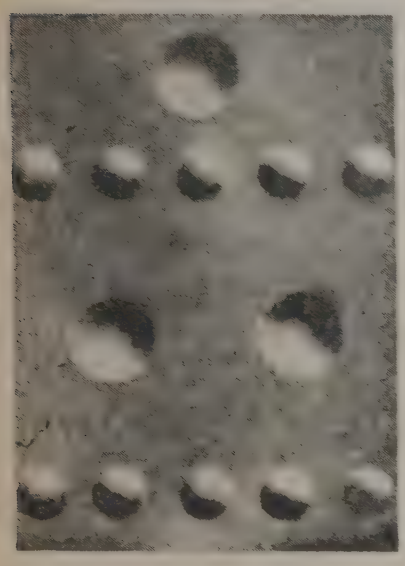


Observe the cubes. They will appear stacked one over two over three — total six cubes. Go on turning the figure by 30° and each time you will see *seven* cubes stacked two over three over two.

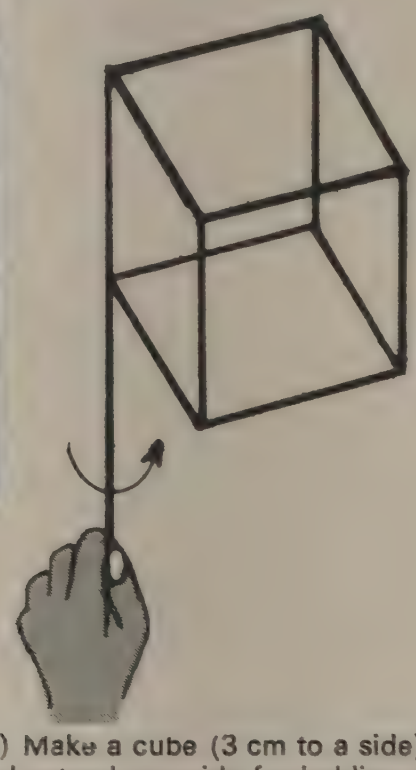




(Left) Here's a folded sheet of paper. Can you tell if the opening of the fold is towards or away from you? (Right) You can see a tapered box. Which way is the opening? Towards you or away from you?



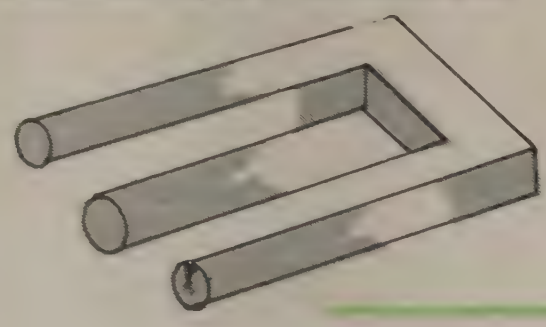
(Left) Crater illusion. Turn the photograph upside down and the craters will look like domes. (Right) Is it a vase or two profiles facing each other?



(Above) Make a cube (3 cm to a side) of wire and extend one side for holding at a distance of 40 cm from your eyes. Imagine the farthest corner to appear as the nearest one. Now turn the cube about its horizontal axis and you will feel the cube rotating in the opposite direction

The ambiguous lithographs of the late Dutch graphic artist Maurits Escher. At left, "Belvedere", done in 1958, uses the reversible-perspective illusion to draw the "impossible architecture of the building". The figure seated at bottom is playing with a cube similar to the one at right. (Below) "Relativity", a 1953 lithograph, shows another impossible design, based on the reversible-perspective of "up-and-down"

(Below) An illustration of the 'impossible' made possible by drawing a three-dimensional object in two dimensions

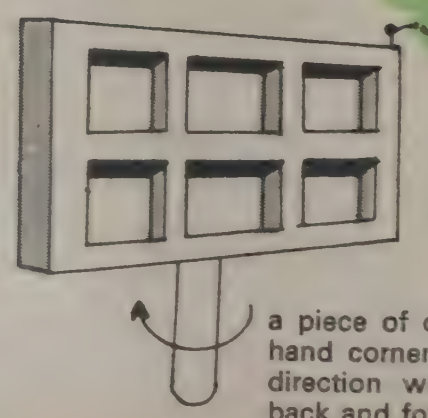


the cage. Perhaps now you understand how cinematogr films create the illusion of mo ment. The movie camera c tures the action by taking series of still pictures at regu intervals; the projector flas these pictures on the screen at same frequency. The illusion movement arises from the phe menon of 'persistence of visio of the human eye. The still p tures appear on the screen ma times a second — for norm movement, the rate is 24 fra per second; there are 16 fra per 30 centimetre of film — a the dark intervals also appear same number of times, but we the image as a continuous act and not as separate individ still pictures because the retains the image of the earl frames by the time the subsequ frames come up.

Meanwhile, le end this article with a few co ments on the speed of light. H great is the speed of ligh Roughly, it is 1,86,284 miles about 3,00,000 km per secon This tremendous speed of light used by astronomers to give measure of the distance heavenly bodies. The light fr the Sun takes some eight minu to reach the Earth. And tha insignificant compared to t stars whose distances have be calculated by thousands and ev millions of light years. (To f the distance of one light year kilometres, you will have multiply 3,00,000 by 60 × 60 24 × 365 !)

Light is the fastest moving age cy in the universe. No mater particle can reach the speed light, because if it did, it wou become infinitely heavy. T explanation lies in the domain higher physics and we cannot into it here.

TRAPEZOIDAL WINDOW



Cut a window (12 cm × 12 cm) f 1 cm thick thermocole sheet. Paint depths in grey and black as shown in drawing. Fix a nail so that the wind and the nail can rotate freely in a h drilled in a wooden block.

Place the frame on a table in a darke room, and light it by front and s illumination from two lamps shiel from the viewers' eyes.

Rotate the model slowly. You will the window rotating first in one direct and then in the opposite direction. Pa a piece of coloured paper (or balloons) at the top rig hand corner. The paper will appear to rotate in the sa direction whereas the window model will still oscil back and forth.

You can heighten the effect if you can connect the mo to a slow-speed cell motor.

t-specificity in insects

CTS AND HOST-SPECIFICITY
eedings of the symposium on
lems of Host-specificity in
s" held at the Entomology
rch Unit, Loyola College, Mad-
January 1976), ed. T. N.
hakrishnan, The MacMillan Co
lia Ltd, 1977, pp. 127, price
entioned

recent years, publication of
ceedings of symposia has be-
ne a (welcome) vogue, at least
international level. Generally,
publications are pre-planned
adequate if not generous finan-
y gubernatorial agencies and/or
blishers) to incorporate general-
introductory lectures for the
s sub-heads/sections, apart from
pecialised papers. The actual
edings are reported almost ver-
, and the participation is usually
rous! What results is generally
glomerate of delight and instruc-
even to the layman, and of
nse value to the specialist.

first glance, *Insects and Host-ity* seems to cover a lot of ground
a galaxy of contributors, and a
g names thrown in. But a closer
ny reveals the limitations in
expertise and even region-wise
entation. A few renowned names
field are conspicuous by their
ce. Of the subject, some areas
e relatively parsimonious atten-

st-specificity in insects is a fasci-
g field of research which can
both academic insights and
ific techniques for better pest con-
insects choose particular plant(s)
ed and thrive on, based on the
rence of various chemical and
ional allurements in the latter.
estingly, apart from, and some-
in spite of, adequate nutritional
lates, a host with secondary plant
ances (with no functional signi-
ce to the plant and of no nutri-
l value to the insect) determines
nitial choice or rejection of the
plant by the insect. Interactions
e intrinsic, extant physiological
, and the behaviour and life
rns of the insect with the chemi-
constitution and ecology of the
also come into play in the final
lishment of an insect on specific
plant(s). Field bionomics, that is,
iations and inter-relationships
een specific insects and plants in
re forms the first step or the
ching pad for research in host-
ficity.

Dr. Ananthakrishnan's compilation contains several contributions in the last category. The same cannot be said of the other, equally important, aspects. Physiological and behavioural aspects of host selection receive comparatively inadequate coverage. There is no full-length paper on host-seeking behaviour in agricultural pests and just one paper each on secondary chemical substances, morphological correlates and other chemical constituents (growth regulators). These and some other papers, for example, on biological control, vectors and parasites, provide redeeming variety from the plebeian recitations of bionomics and/or some banal reviews.

A sore point is the extreme brevity of most papers, attributed by the editor to the economics of production costs. This forced condensation of material is perhaps responsible for the dubious hue of the more sketchy presentations. Presumably, also, similar or other reasons have prevented a more balanced and broader participation. Recent trends such as the application of the computer technology to the construction of models of insect host-seeking behaviour in the concatenation of ecological parameters — which are being tackled in India also — are not even mentioned in any contribution. Similarly, the importance of electrophysiological studies, though gratuitously mentioned in a couple of papers, is neither sufficiently elaborated nor even adequately introduced for the uninitiated by reference to the great pioneering achievements in this field (for instance, of the Danish scientists). The cross-section provided by the book of the many-faceted problem of host-specificity in insects is, therefore, neither sufficiently comprehensive nor even representative of all those aspects which are actually being studied in India itself.

The absence of discussions at the end of each contribution is also a lamentable omission, for perhaps the liveliest and most valuable insights often emerge from the loud, free-thinking stirred by the debates following the presentation of a paper. In fact, the compilation can hardly be called "Proceedings" in the absence of these invigorating tail-pieces. The editor, however, has been far-sighted in giving reference citations in full.

The book has its value as a compendium of pest-plant relations specific to this country, specially to new workers in the field. Its interest, readability and digestibility for the layman or any distinctive specialist value in the individual contributions is restricted to a few select papers as a whole and to patches only in others. With the given subject, more funds and wider participation, the editor, who is well known in Indian scientific circles as an indefatigable crusader and incomparable organiser, could undoubtedly have produced a memorable volume. Dr. Ananthakrishnan nevertheless deserves congratulations for at least attempting to focus the spotlight on some of the current Indian research in this interesting field.

R. N. SHARMA

[Dr. Sharma is Entomologist with the National Chemical Laboratory, Pune.]

On gene expression

CONTROL OF GENE EXPRESSION by Norman Maclean, Academic Press, London, 1976, pp. xi + 348 (£ 7·80)

The control of gene expression is still not well understood, whether in lower or higher organisms. There are some vague ideas on how the control of gene expression is accomplished in bacteria. However, we are ignorant of this process in higher organisms, that is, eukaryotes, except that it probably involves complex processes. Therefore, the author has not devoted the book to explain how gene expression is controlled in eukaryotes but has rightly laid stress on the discussion and comparison of the experimental systems currently being used to probe this problem.

The book, therefore, mainly deals with the various eukaryotic experimental systems — from the simple systems involving only one type of protein (immunoglobins, lactate-dehydrogenase, hemoglobin, etc) to systems not yet well understood in molecular terms (slime moulds, *Acetabularia*, *Hydra*, imaginal discs of *Drosophila*, etc) through systems of limited complexity (pancreas, yeast, muscle, *Aspergillus*, *Neurospora*, etc). The discussion on the imaginal discs in *Drosophila*, in chapter 5, is excellent.

SUBHASH S. ARORA

[Mr. Arora is an Indian Council of Agricultural Research scientist-designate with the Department of Genetics, Haryana Agricultural University, Hissar.]

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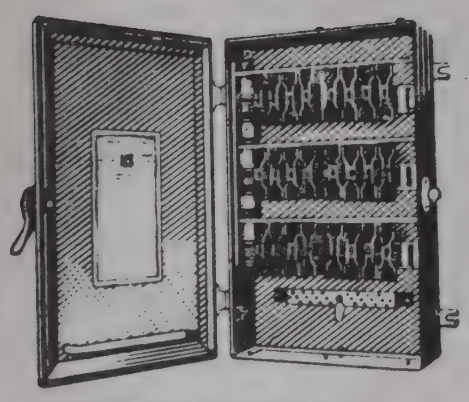

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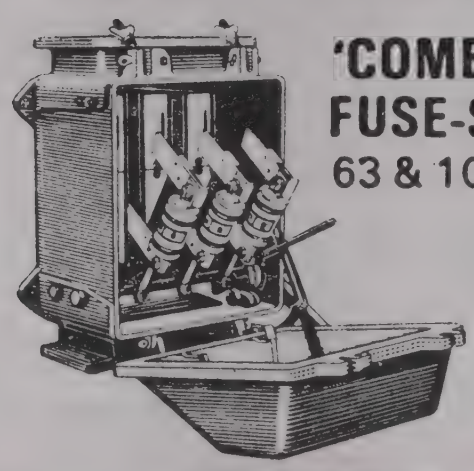

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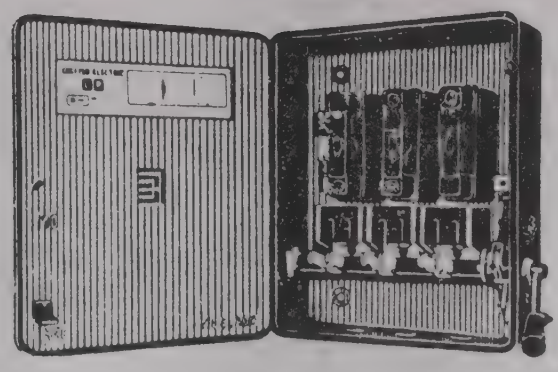

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hat are the distinguishing characteristics of various kinds of cassettes in the market ?

ith ever so many types of cassettes in the market and all kinds of claims made on their lf, the cassette-recorder owner is to be foxed, or at least be-ered. He will do well to remember a cassette will give the perform- claimed for it only when the rder has the necessary adjustments as for ' bias level ').

ne magnetic recording cassette ally consists of a non-magnetic such as cellulose acetate, poly- or PVC coated with the very particles of magnetic material as ferric oxide. This tape is moved constant speed across an electro-netic recording head. The magne-flux provided by the recording , representing the audio signal e reproduced, provides the corres-ding magnetic pattern on the very magnetic particles on the tape. playback operation, the pre-rded magnetic pattern is scanned he same or similar head which verts them into corresponding trical impulses. This is what is cally done by a cassette tape rder.

practice, things are not that ble. The relationship between the rding head and the magnetic tape ery complex. The frequency res-se, for audio-frequency spectrum, ny tape is far from ' flat '. Thus, the tape recorders have an ultra-c frequency oscillator which sup-s the ultrasonic bias current to the rding head along with the signal e recorded. The magnitude of this signal is much more than the io signal to be recorded. This bias al ' churns up ' the fine magnetic ticles on the tape and demagnetises m, so that the recording signal has uch easier job to do. Then comes equalisation of the frequency res-se. This is done in two parts. While rding and while playing back, the yback equalisation is standardised that a cassette recorded on one order can be played on another.

The third thing is the dynamic ge, ie, the span between the softest d the loudest signal the tape can ndle without any distortion. By reasing this range, the signal one ords can rise higher above the back-und noise level, called ' hiss ', pre-t on all magnetic tapes. This proves the signal-to-noise ratio, d one hears less hiss on low volume ssages of recording. (The above is also plicable to reel-type tape recorders.)

These characteristics, ie, the bias, equalisation, dynamic range and hiss, are where the different cassette types and brands are at variance with one another. " Extended frequency ", " high output ", " low noise ", " super ", " ultra ", " dynamic ", " high energy ", " cobalt doped ", are the different epithets representing some of these characteristics of the magnetic tape. In most of these cassettes, ferric oxide is the basic magnetic material. The finer the magnetic particles and the greater the density of these particles, the lower the noise, the more the output, ie, extended dynamic range and better high frequency output. Chromium dioxide is one of the new magnetic materials used in cassette tapes. The output of these chromium dioxide cassettes is quite high. The frequency response, on the higher side of the audio spectrum, is much better in comparison with ferric oxide and its derivatives.

Different types of ferric oxide cassettes require different low, medium or high bias levels. The chromium dioxide cassettes require still higher bias level. Except for professional cassette recorders, the direct or indirect adjustment of the bias level to suit the type of cassette used is normally not provided by the recorder manufacturer. Almost all standard portable or average household tape recorders work on fixed bias system and their electronic amplification works on limited audio frequency spectrum. Thus, the modern tapes, whether derivatives of ferric oxide or chromium dioxide, may not provide all the advantages claimed for them unless the recorder has the provision to optimise the bias level. On the other hand, the chances are, these modern cassettes may give sound inferior to their older counterparts.

NOTE: Except for chromium dioxide, all other magnetic materials, as explained above, are also used on conventional reel tapes. Chromium dioxide gains its importance only because the cassettes are operated at the speed of 1 7/8 i.p.s. This speed is low in comparison with reel tapes. At the reel tape speeds, the characteristics of ferric oxide type tapes become comparable with chromium dioxide.

ANIL V. BORKAR

Mr. Borkar (30), a radio and electronics engineer, is technical director of an industrial electronics concern in Bombay. He holds patent rights for devices like a radio-controlled electronic switch for radio and TV sets (developed when he was 18), fire alarm and photoelectric device. He has won awards from Esso, the Inventions Promotions Board and the Mahratta Chamber of Commerce and Industries. He has been associated with SCIENCE TODAY almost since its inception, as a contributor to " You Too Can Do It."

" Do you have one that will remind my wife she has overdrawn ? "

BRAIN TEASERS

CAROM WITH A DIFFERENCE : Mr. Shambhu is an unorthodox referee. For example, in his game of carom, he uses only white pieces, 25 in all. Two players are to play one strike alternately. For each successful strike, a player gets one point and for each unsuccessful one, the opponent gets one point. In one game, there were seven unsuccessful strikes in all and when the score was 9–8, Mr. Shambhu closed the game and declared the one who got nine points the winner. Was he the first striker or the second?

V. A. SHENAI

(Solution next month)

Solution to last month's Brain Teaser

Swamiji's devotees

Let there be m men, each getting x flowers.

Then $mx + (12 - m)(x + 2) = 142$

Simplifying, $6x - m = 59$

or $x = 9 + \frac{5 + m}{6}$

For m and x to be integers, for men to outnumber women and for m to be less than 12, m is 7 (and hence there are 5 women) and $x = 11$. Hence, each man got 11 flowers and each woman, 13.

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Y CELL RECHARGER

e name " dry cell " is really a isnomer, as no cell which is dry deliver any appreciable current. most widely used and readily able dry cell is a special form e Leclanche cell. Since this type ll is relatively very light and ble, it has practically replaced types of primary cells. The main of these dry cells becoming usted is their really becoming

e anode is the zinc container of ry cell; the cathode is a carbon ocated axially in the zinc con-r. The paste-like mixture of anese dioxide, ammonium chlor-nd crushed coke, pressed solidly he container between the carbon and the separator, acts as an olyte. The top of the container aled with tar or a similar ound.

e emf of torch cells, when new, om 1·5 to 1·6 volts. This emf even though the cell remains or a long time. The shelf life of ell is limited.

the cell delivers current, due to ochemical reaction within the the manganese dioxide loses en while the zinc of the container idised which gets dissolved in the olyte. If this process continues long time, the zinc container ops cracks or holes and thus stop the electrolyte from leaking If you recharge the cell before reaction proceeds very far, you estore the working of the cell.

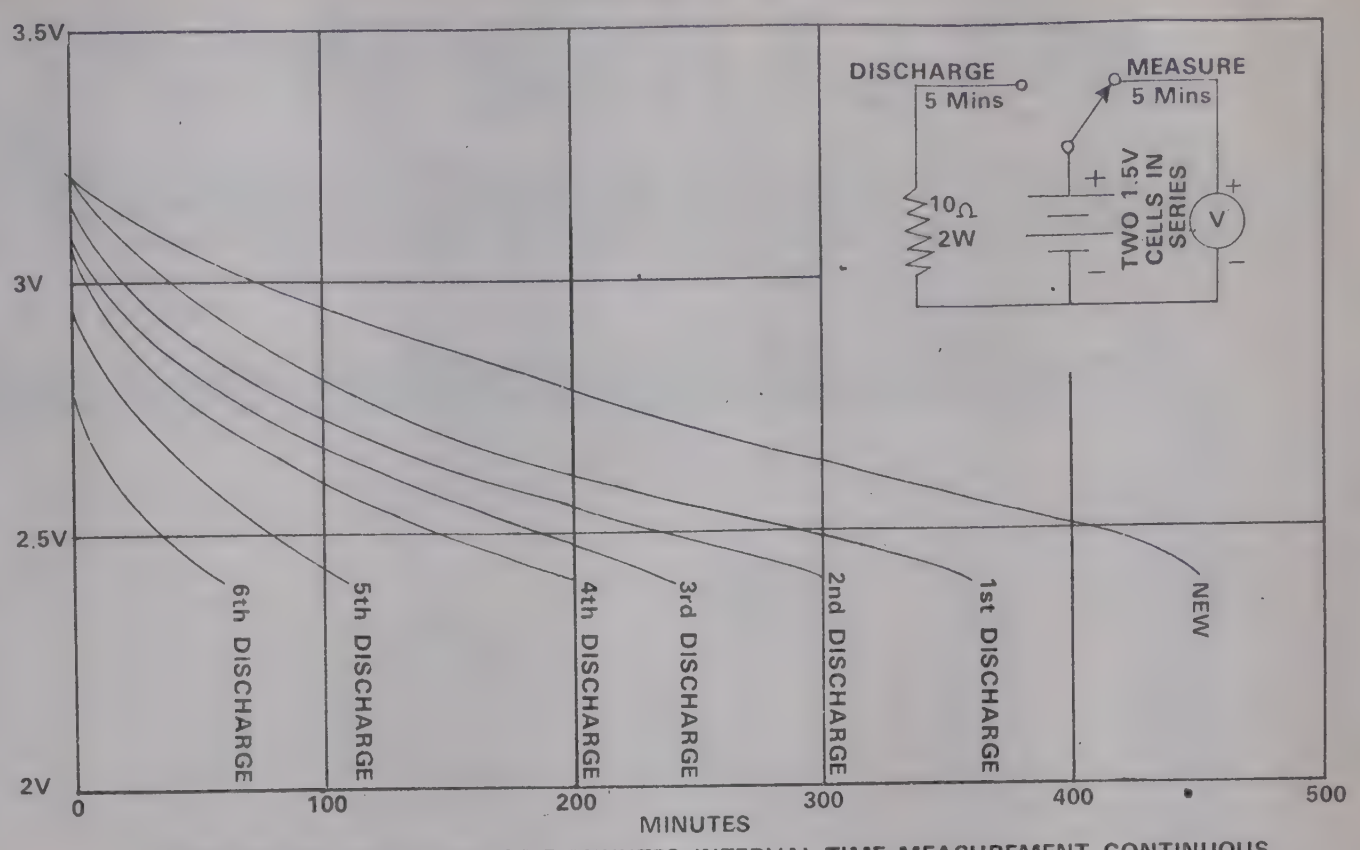
echarging the dry cell is a process ar to electroplating. The re-ging current, which is in the se direction (that is, cathode to e) to the flow of current inside cell while the cell is in use, es the dissolved zinc oxide from electrolyte and deposits the zinc on the zinc container. The en, in the same way, is returned orm the manganese dioxide. The ity of the recharged cells depends their age and how they were used n they were new. Those cells ch have been used in the normal manner and then put to charge soon after do take and hold the charge. A fully discharged cell will not be able to hold any charge. To get a longer recharged life from a cell, you must interrupt its service life when its voltage drops just below 1·2 volts. Recharge the cell, depending upon its type No., for about 6 to 12 hours and put it back into service. In this way you can extend the life of these cells by about three-fourths. However, these recharged cells have a comparatively poor shelf life.

The dry cell recharger, as explained below, is suitable for simultaneous charging of two 1·5 volt cells connected in series. It has very few components. The standard step-down transformer provides 6·3 V AC to the silicon rectifier, BY 126. The 10 ohms 2-watt resistor in series with it is for limiting the charging current. The 150 ohms 1-watt resistor, in parallel with the rectifier, provides about 10 per cent ripple current. This ripple current, along with the DC current, helps even out the deposition of the zinc on the inside of the zinc container.

Experimentation: In portable cassette recorders, record players, battery operated toys and radios, the cells are generally never used continuously. Thus, the cells get sufficient time to recover when not in use, and provide comparatively longer useful life than if they were used continuously. To evolve the discharge characteristics of two cells in series, under various conditions like new first charged, second charged, cells under accelerated discharge condition etc, the following experiment was done. The changeover switch was alternatively kept in " measure " and " discharge " positions for five minutes. Every time the switch is in " measure " position for five minutes, the cells get sufficient time to recover as the current drawn by the voltmeter is negligible. This procedure was continued while taking the voltage readings, till the voltage shown by the voltmeter dropped to 2·4 volts. When this level is reached, both the cells were removed and put on the charger continuously for nine hours. After the charging period, the cells were kept idle for about an hour and then subjected to the same discharge pattern. The discharge characteristic curves (see above) show the usefulness of the charger.

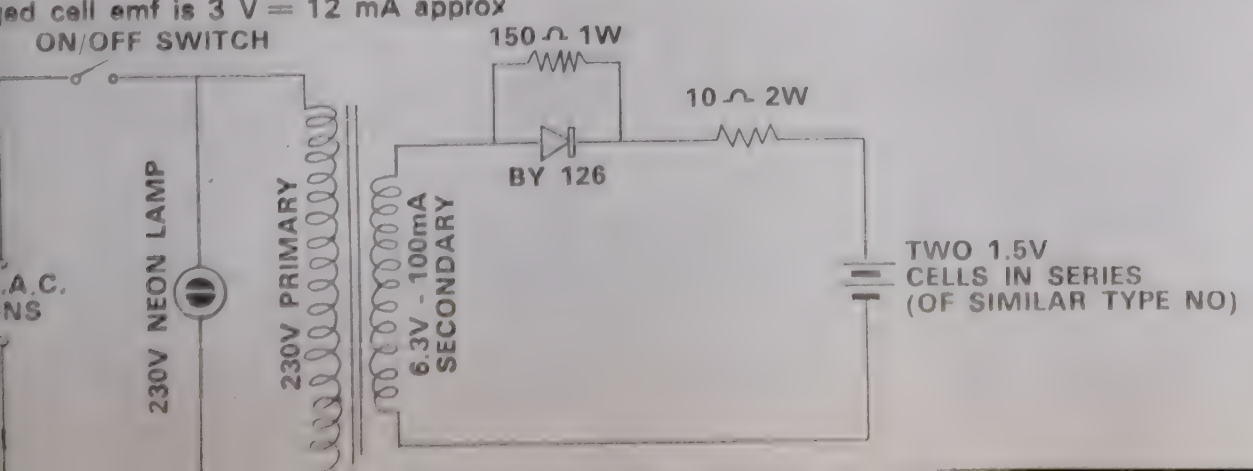
(*Note:* Don't keep the dry cells in the charger when the charger is not connected to the mains supply. Otherwise, the cells will discharge through the two resistors and the transformer winding.) Approximate cost, Rs. 25.

DISCHARGE CHARACTERISTICS WITH CELL TYPE 1035



INTERRUPTED DISCHARGE OF 5 MINUTES INTERVAL TIME MEASUREMENT CONTINUOUS

DC charging current (1) when the discharged cell emf is 2·4 V = 25 mA approx. (2) when ged cell emf is 3 V = 12 mA approx



You will need:

Silicon Rectifier: BY126 or BY125, 1 no;

Transformer: Pri: 230VAC;
Sec: 6·3V — 100mA, 1 no;

Resistor: 10 — 2W, 1 no; 150 1W, 1 no;

Misc: 230V neon lamp, battery holder, two cells, ON/OFF switch, wires, solder, screws. suitable enclosure, etc.

ANIL V. BORKAR

Cell type no.	Recommended charging duration
1015	4—6 hours
1035	6—9 hours
1055	12—15 hours

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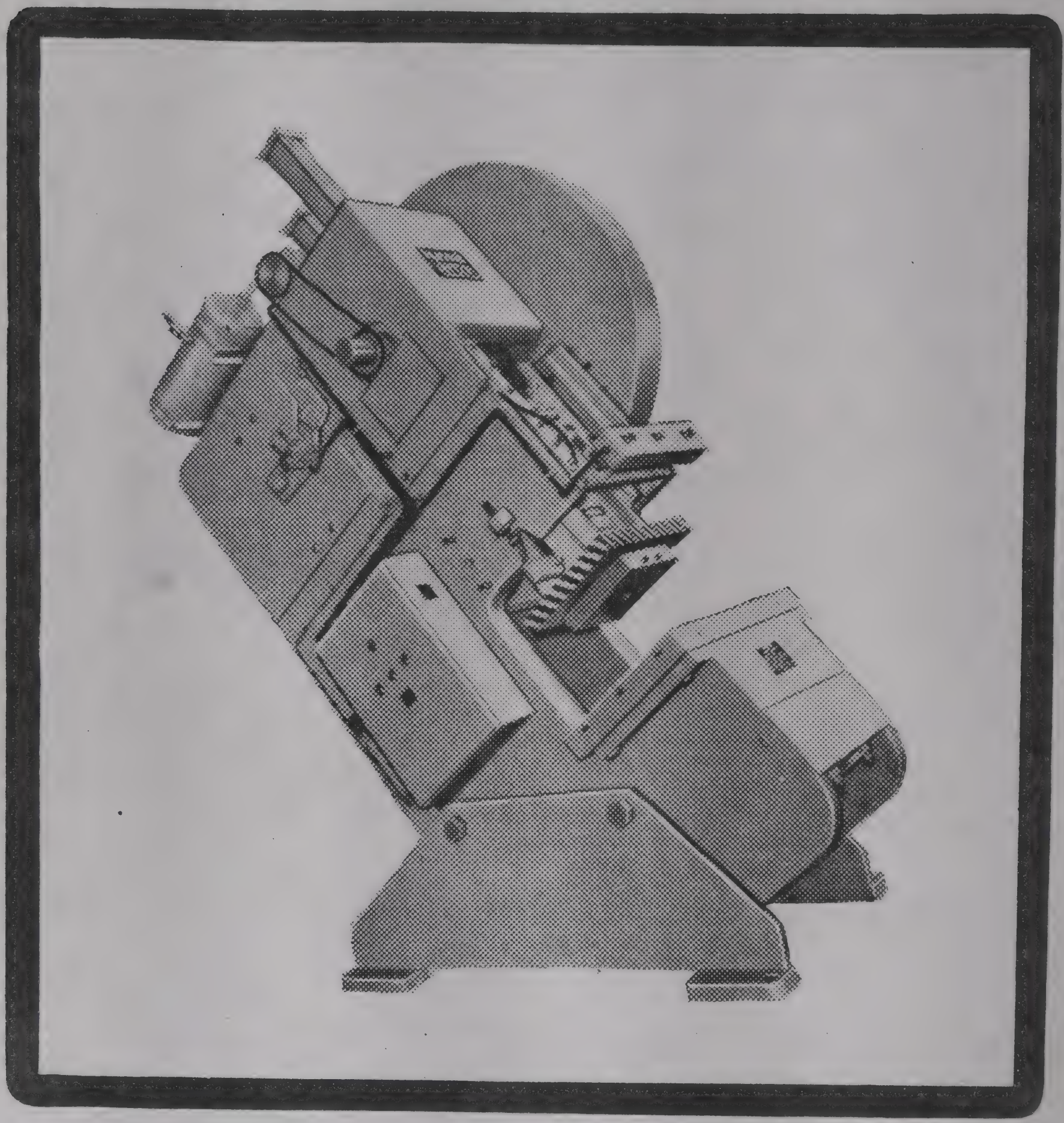

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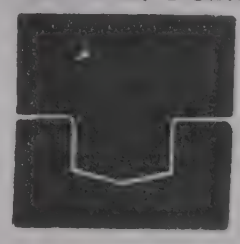

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ELL US WHY...

they say animals use their tails for about every purpose imaginable?

use it's true. Take a squirrel's bushy tail. It is a steering when the squirrel is making its big arboreal jumps and a ng parasol when the squirrel is picking its way along fine When squirrels miss their footing and fall (they sometimes plumy tail acts a parachute so effectively that squirrels lunge from heights of 15 or 18 metres without suffering ury. Then, the bushy tail is a warm wrap-around in cold r. An Arctic fox, for instance, sleeps with its tail curled over the tip of its nose. A tail is also of incalculable help ing a predatory enemy misjudge a pounce: a predator, after its victim, is likely to jump at the waving tail; all it a mouthful of tail fur while the tail-owner gets away.

rue that mice use their tails to get food out of inaccessible ? Often one can hear animated debates on this point. t's true. If a mouse finds an unstoppered jug of, say, es, it will sit atop the neck, lower its tail into the jug (like lowers a bucket in a well), and haul up the sweet stuff by tailful.

ke the case of the kangaroo's great heavy tail. It leans back ops itself on it, as a man does on a shooting stick. Even izards use their tails that way. The original monster lizards certainly swung their tails as weapons, in a carry-over he tail-swinging technique of fish. The crocodile, too, uses as a weapon. So does an ant bear. It thwacks with its powerfully as a bear with its forepaw.

serve as fly-swatters, as signals, as instruments of com- ation, as extra limbs and tools of many uses. A woolly ey curls the tip of its tail into a circle, plants this loop on ound, stiffens the rest of the tail into a supporting column, as a portable chair! A honey bear, raiding a nest of bees, head downwards and then, when it wants to make its ay, climbs its own tail. Pangolins, which are scaly anteaters in west Africa, block their burrow entrances with their red tails.

le there are almost as many tail uses as there are animals, are also some popular notions about animals' tails that true.

instance, it is said, if you pick up a skunk by the tail, the can't discharge its malodorous spray. Well, it is true that times a skunk, captured by the tail-grabbing technique, fails to se its stench. This may be either because the particular is exceptionally affable (all skunks, by the way, are placid, lly animals, and don't ordinarily discharge their sulphide s extremely frightened or harassed!), or it may be because tench-releasing ability varies from skunk to skunk. The fact remembered is that great many skunks can and do function as effectively when hoisted by their tails as under any other mstances.

SUDHIR GHATNEKAR

AWARDS & APPOINTMENTS

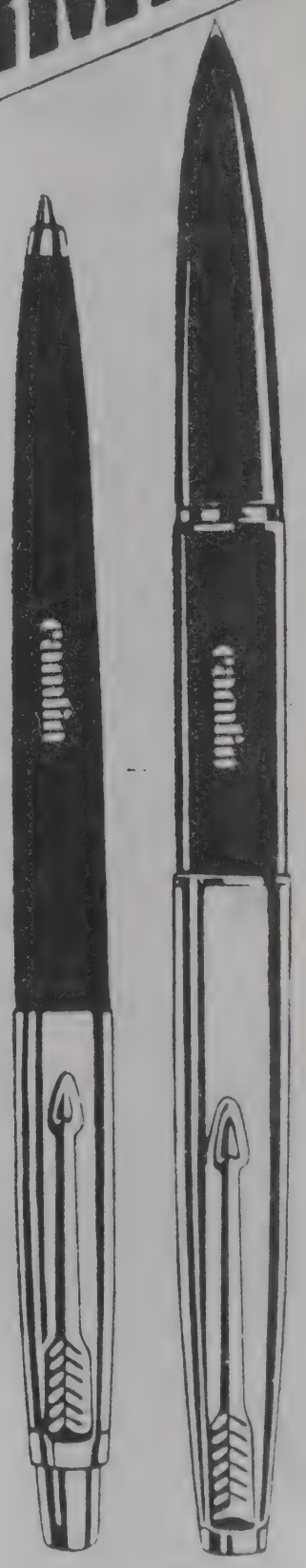
C reconstituted

he Atomic Energy Commission has been reconstituted with e new members. The new Commission consists of: Mr. H. N. na (Chairman), Dr. R. Ramanna, Director, Bhabha Atomic earch Centre, Bombay, Dr. Manmohan Singh, Secretary, artment of Economic Affairs, Mr. Mantosh Sondhi, Secretary, on Ministry of Industry, and Mr. V. Shankar, Secretary to the he Minister. The last three are the new members. They come lace of Mr. M. C. Kaul, Mr. P. N. Haksar, and Mr. P. N. Dhar.

tra heads NCERT

Dr. S. K. Mitra has been appointed Director of the National ncil of Educational Research and Training, New Delhi. Dr. ra, who was Joint Director earlier, had been functioning Director of the Council following the resignation of Dr. Rais ned earlier this year.

STAR PERFORMERS



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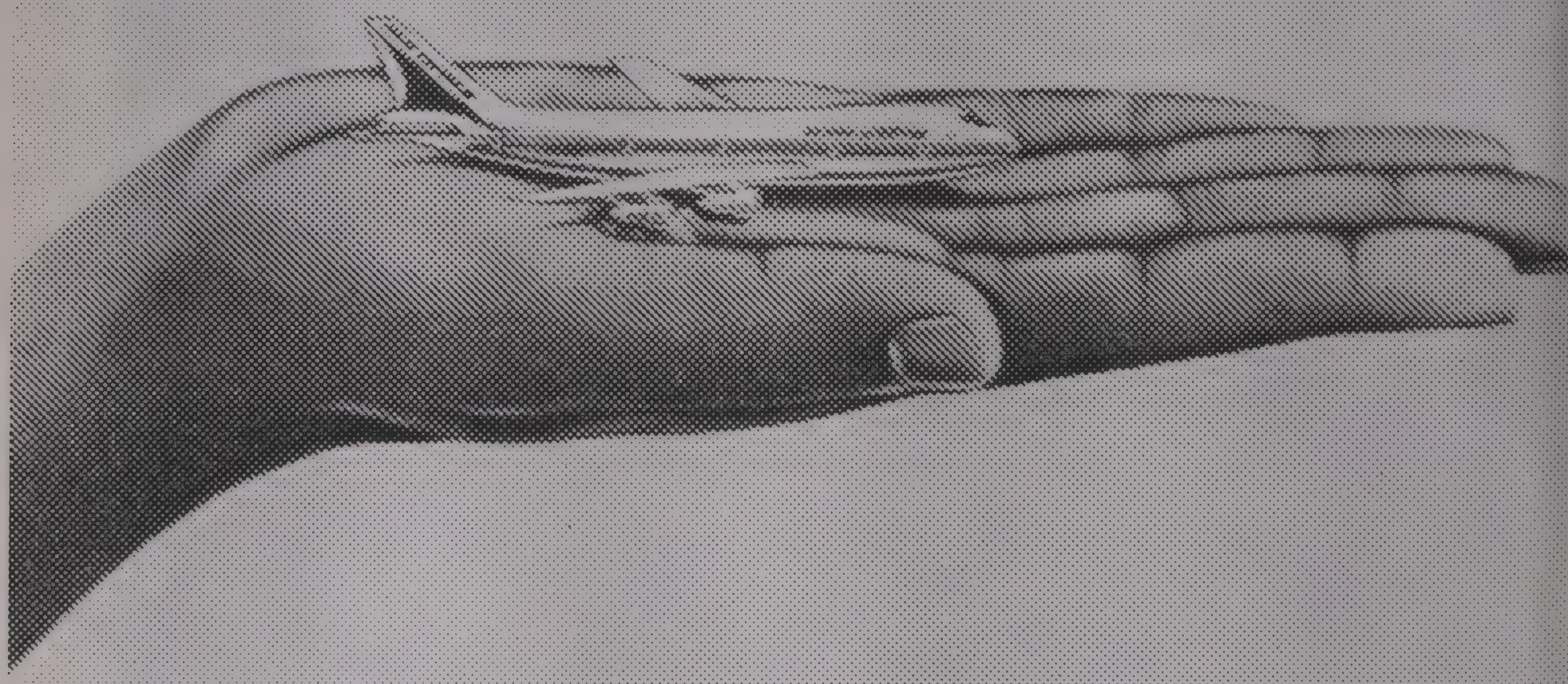

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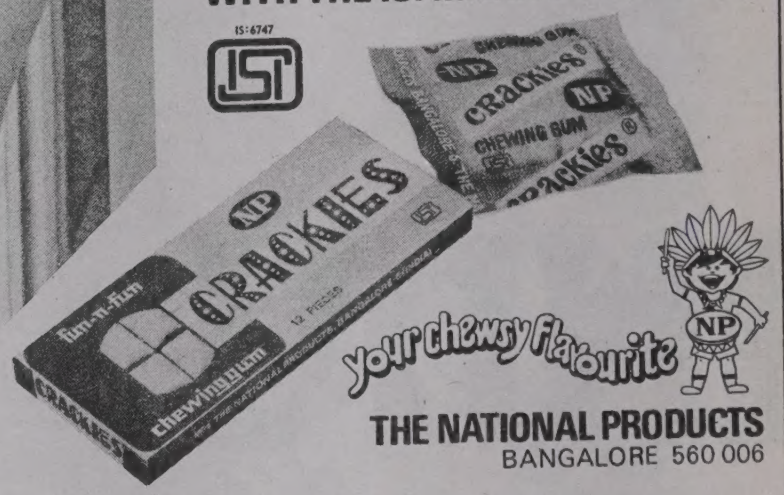

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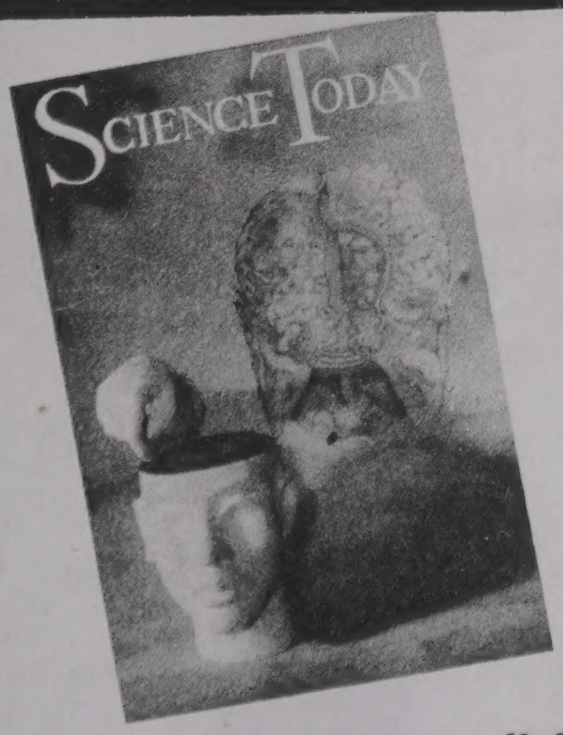

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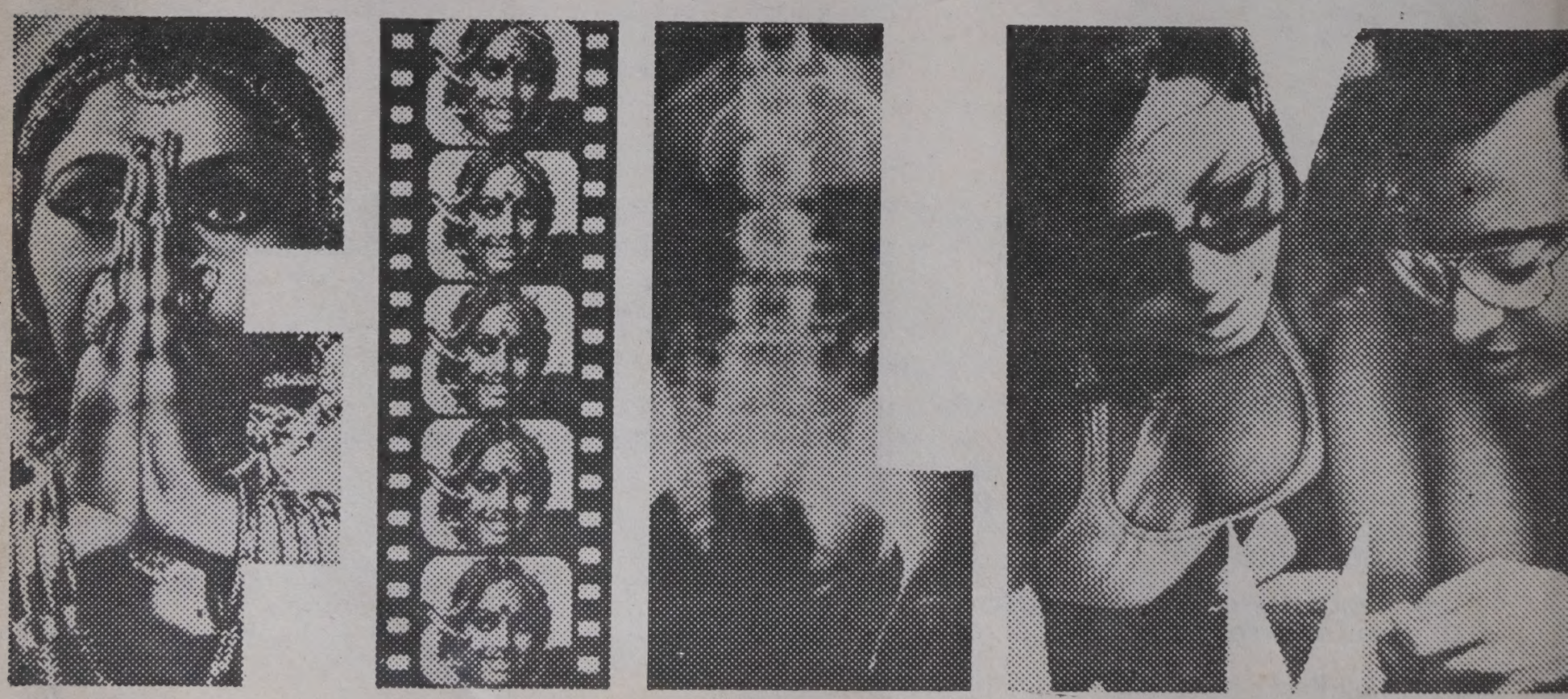

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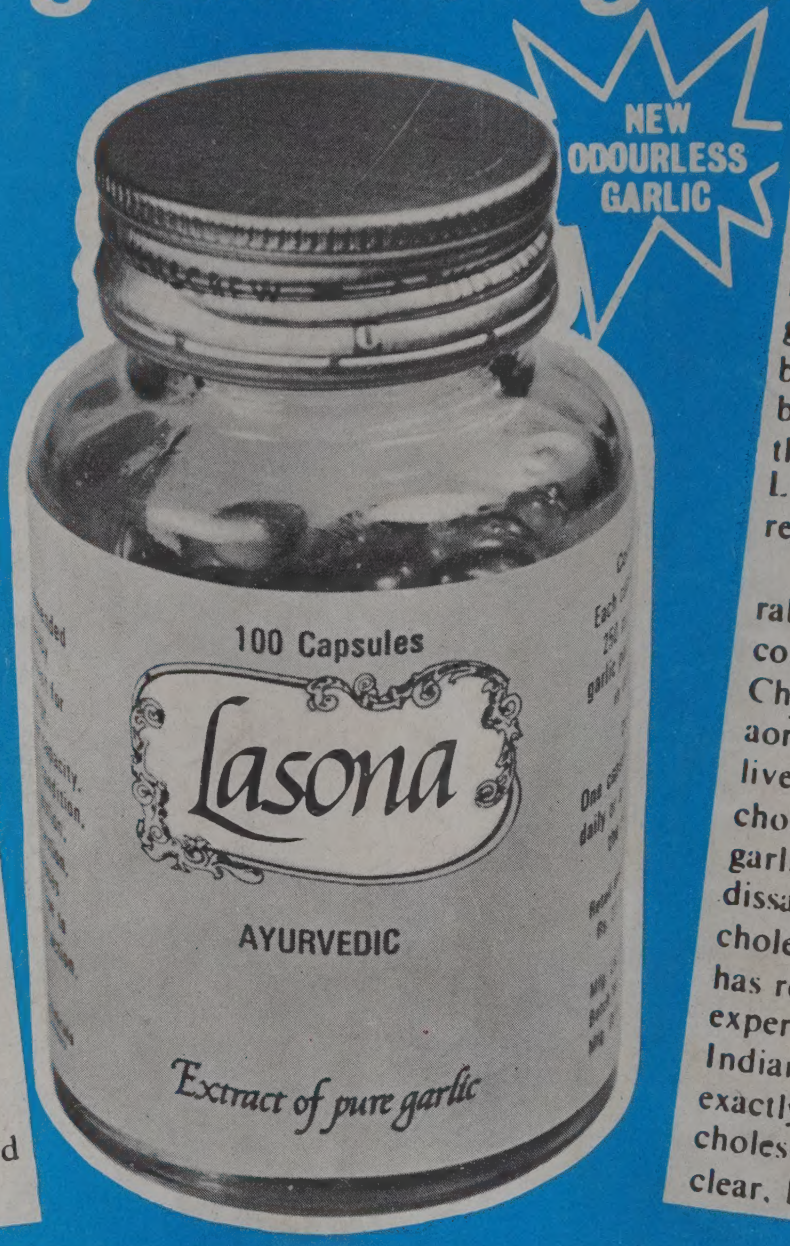
SUNDAY STANDARD

Vijayawada, Sunday October 17, 1976

Raw Garlic is anti-bacterial

NAINI TAL Oct. 29 (Samachar)

Raw garlic possesses anti-bacterial property against a number of micro-organisms including those which are resistant to commonly used anti-biotics. This is revealed in researches conducted at the Pantnagar University. According to the researchfindings, anti-bacterial property of garlic is lost on boiling.



Eve's Weekly

July - 17-1976

AYURVEDA IN YOUR HOME

Suresh Chandra Chaturvedi

GARLIC

Regular use of garlic helps the digestive system and removes gas and constipation. It increases the blood, cures chronic cold and cough Gastric troubles are cured by taking garlic every day.

THE TIMES OF IN

BOMBAY. DEC. 3-1976

Eat Garlic and Cut Cholestrol

NEW DELHI, December 2 medical study has revealed t garlic is effective in reducir blood cholestrol. An experime by Dr. R. C. Jain, pathologist the University of Benghazi in Libya has now shown that garl reduces the cholestrol level.

He did the experiment on rabbits which he fed with a die containing large amounts of Cholestrol for 16 weeks. Their aorta (main blood vessel) and liver were deposited with cholestrol but after giving them garlic, he noticed that the fat dissappeared and the blood cholestrol came down. Dr. Jain has reported the results of his experiment in "The Journal of Indian Medical Research". How exactly garlic brings down cholestrol level is, however, not clear, Dr. Jain said-Samachar.

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